Dr. Dobb's Journal of

Software Tools

FOR THE PROFESSIONAL PROGRAMMER

#117 JULY 1986
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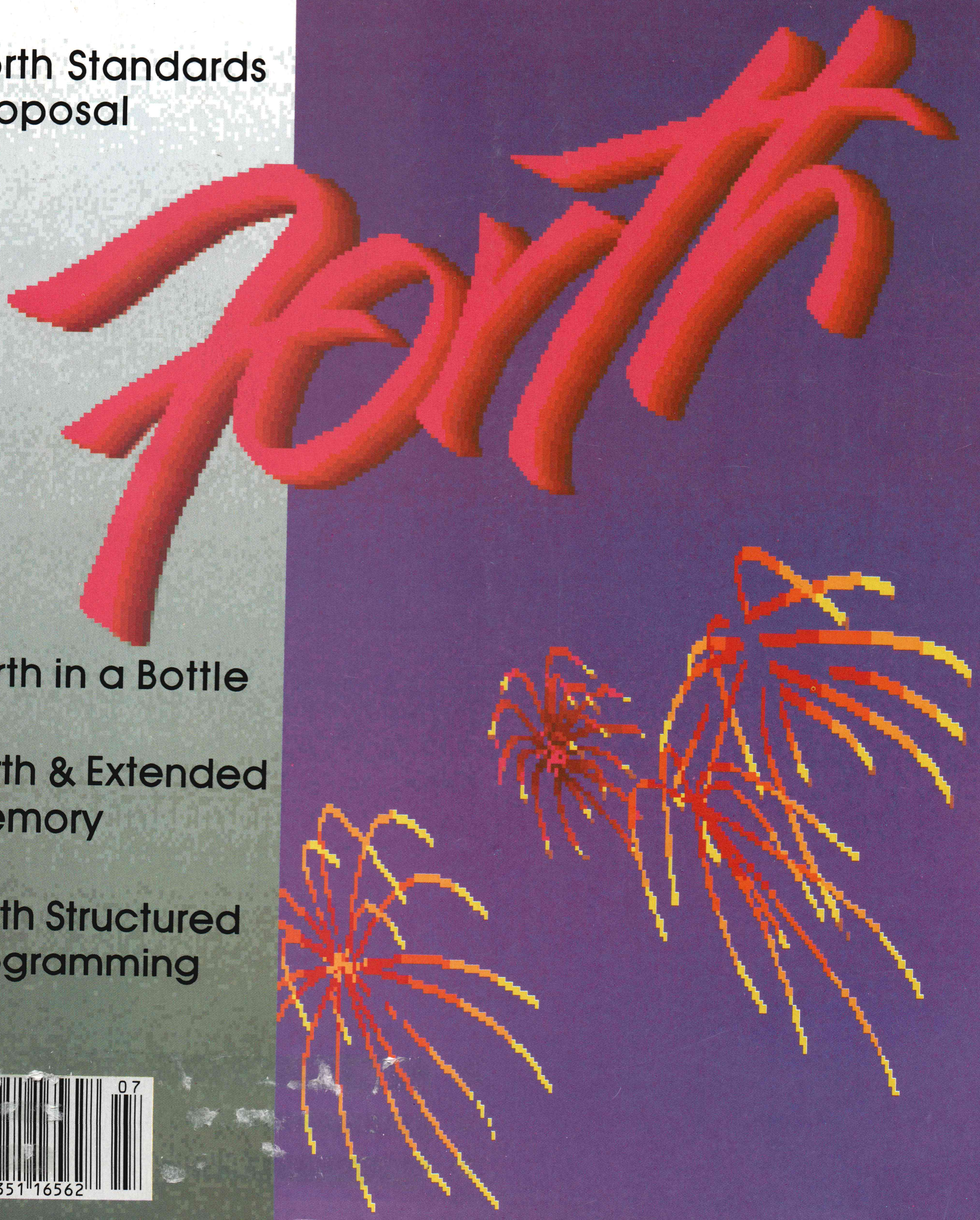
Forth Standards Proposal



Forth in a Bottle

Forth & Extended Memory

Forth Structured Programming

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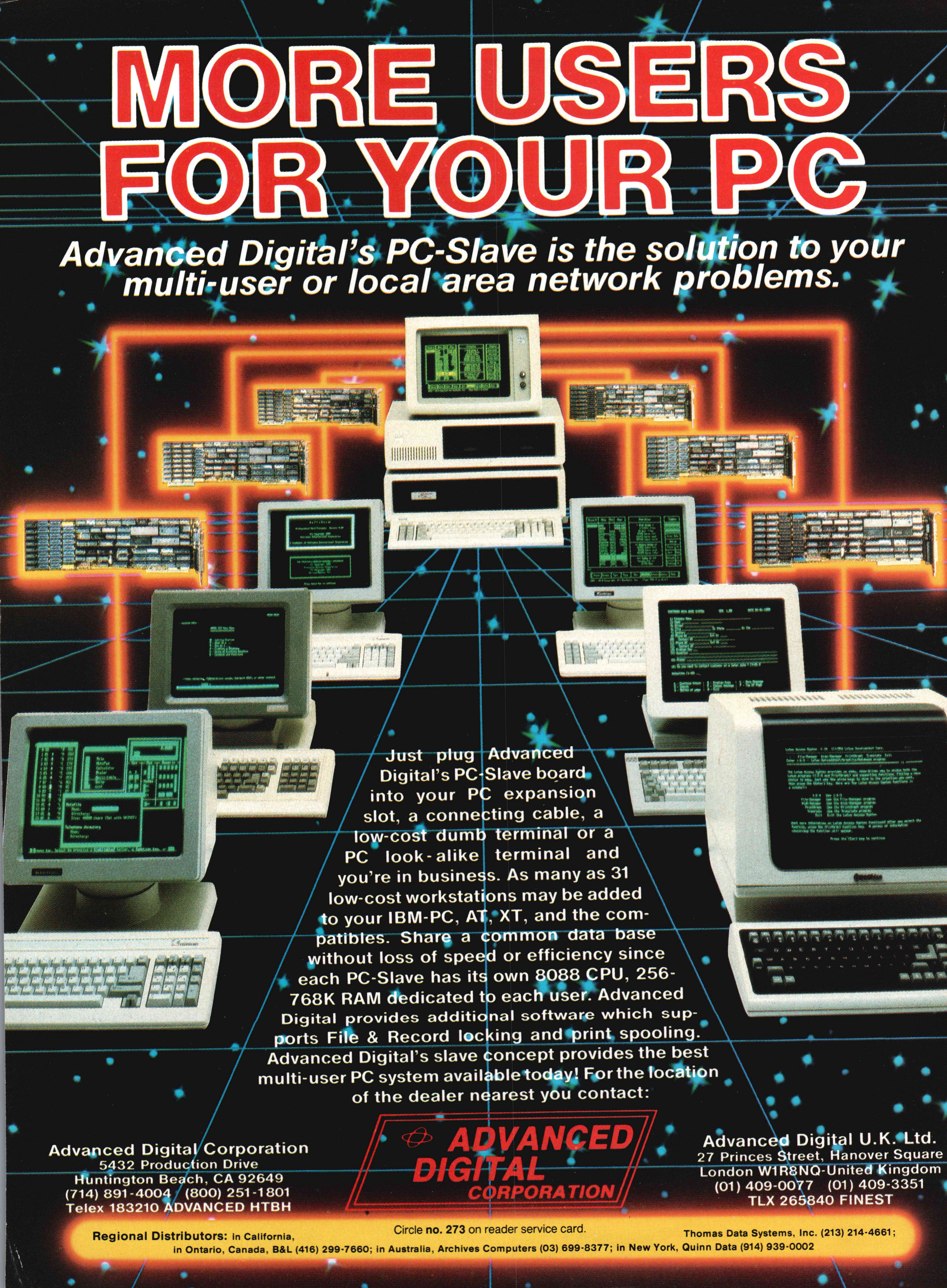

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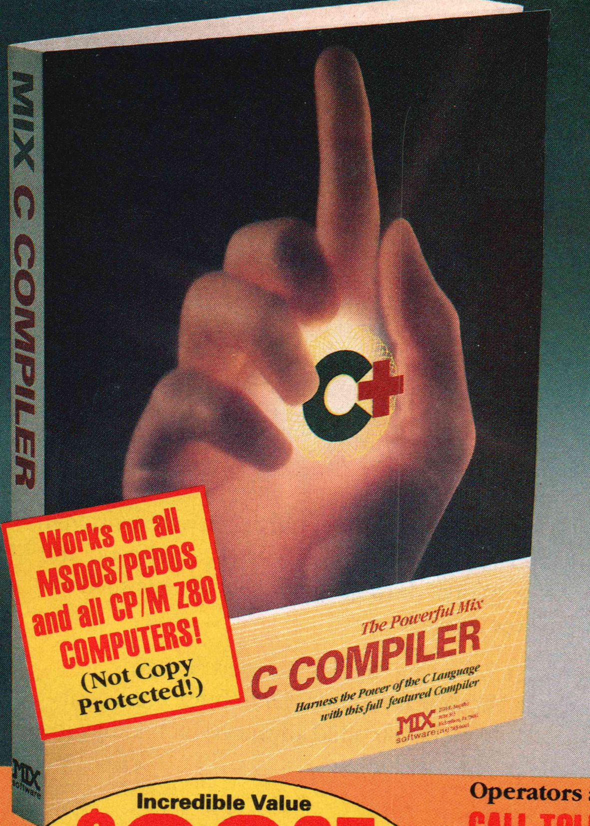

C FEVER *catch it!*

It's becoming an epidemic . . . everyone is switching to C! First there were a few hackers, then came the college students, next the major software houses, and now the rest of the programming world. Programmers everywhere are infected with the desire for SPEED, POWER, and PORTABILITY.

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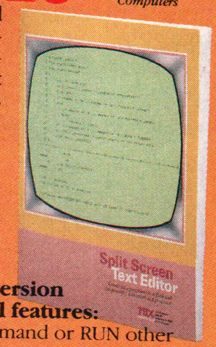

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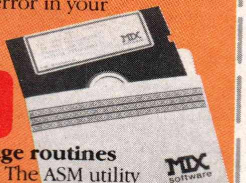

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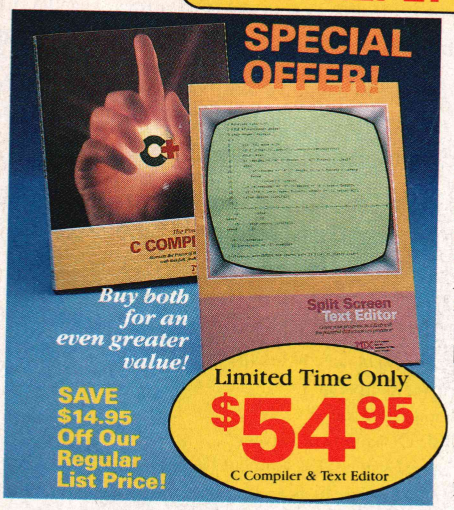

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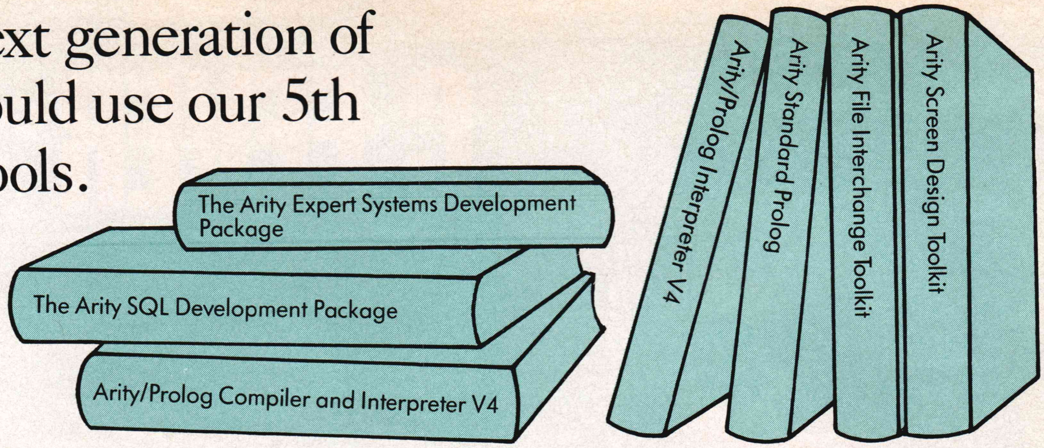

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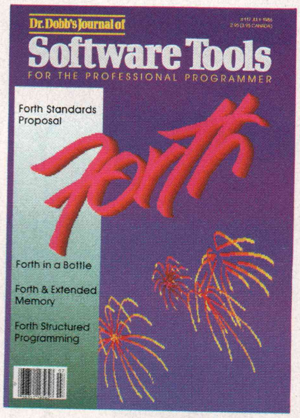

About the Cover

The cover was designed by Janaia Donaldson and created by Dan Silva on a Commodore Amiga. Dan used the Deluxe Paint program he designed for Electronic Arts.

This Issue

Welcome to our sixth annual special issue on the Forth language. Our feature article proposes a comprehensive set of standards for extended control structures. Everett Carter puts Forth in a bottle, and Craig A. Lindley opens a window on easy-to-use implementations. We're also introducing a new columnist whose specialty is—you guessed it—Forth.

Next Issue

In the hot month of August why not dive into C? Last August, we broke ground with a new kind of software review. It was more technical and deeper in detail than the usual fare and used carefully designed "surgical" benchmarks. This year we reprise and improve the process with an up-to-date comparison of 17 C compilers for MS-DOS.

YOUR
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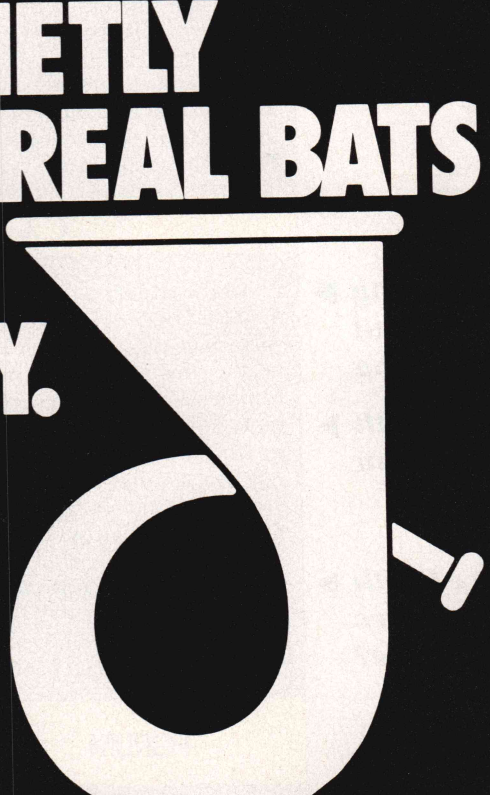
IS QUIETLY
BREEDING REAL BATS
IN YOUR
BELFRY.



WE'RE OUT TO SAVE ONE MILLION FRUSTRATED PROGRAMMERS

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1) write around the problem by creating six pages of emetic code...

2) leave out that incredible idea that really puts your stamp of excellence on this program or...

3) get yourself a world class headache (or a stroke) by dropping into assembler.

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In seconds.

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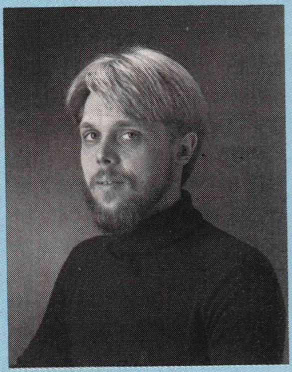
EDITORIAL



Concern has been expressed that we are abandoning Forth. We're not. We have, though, devoted less attention to the language in the past year and intend to redress this, starting with this Forth issue. Michael Ham, our new columnist sharing the Structured Languages column, is an accomplished Forth programmer and one of the most eloquent voices in the Forth community. We're looking forward to publishing more Forth articles in future issues, particularly those that demonstrate the unique advantages of Forth's threaded, extensible, reverse Polish nature.

Michael Odawa, vice president of the Software Entrepreneur's Forum and director of the Software Services Association, sent us a letter about a new set of tax regulations that are up for consideration here in California. The new legislation, if passed, would be grossly unfair to independent software authors. Briefly, the proposed revision to the State Board of Equalization's Regulation No. 1502 would apply a sales tax of 6-7 percent (depending on the county) to all software royalty income, as well as some software-related business transactions (such as installation and maintenance of software). Neither of these forms of income is currently subject to sales tax, and neither should be—both represent charges for labor, not sales of physical assets. This ruling runs completely contrary to Sections 6011 and 6012 of the Revenue and Taxation code, in which labor charges are explicitly excluded from sales taxation.

One key issue here is the distinction between services and manufactured goods. Under the tax code, services are not subject to sales tax. The new legislation would make the medium used to deliver a new piece of software determine the taxability of the sale.

If you're a software author in California, this law would directly affect you. If you live elsewhere, you should be aware that wide-ranging legal precedents can be set by such legislation. Mr. Odawa can be reached through the Software Entrepreneur's Forum at (415) 854-7219. We urge programmers to educate California state legislators about this legislation.

Authors often ask, "How do I write a manuscript that you will want to publish?" Call me directly, tell me about your article, and make sure I send you copies of our *Writer's Guidelines* and *Style Sheet*. But that's only the first step. There are so many "good things to know" about writing for magazines that whole books have been written on the subject. Starting this month, I'd like to bring you some advice of my own. If you're working (or thinking of working) on an article, read on.

Keep in mind that space is often at a premium. Explain (briefly) what the problem was that you solved and explain the solution. Then summarize briefly and mention where your software is available.

Now is the time to get to work on articles for the next 68000 issue (January 1987). The deadline for that issue is September 15. Remember, if you get your article to me well before that date there will be time for rewrites—otherwise, if it's not perfect it might not be published. If you have any ideas you'd like to discuss, give me a call at (415) 366-3600.

Nick Turner
editor

Dr. Dobb's Journal of
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MS-DOS, PC-DOS, CP/M-86, XENIX, 8086/80x86 ROM

Manx Aztec C86

"A compiler that has many strengths . . . quite valuable for serious work"

Computer Language review, February 1985

Great Code: Manx Aztec C86 generates fast executing compact code. The benchmark results below are from a study conducted by Manx. The Dhrystone benchmark (CACM 10/84 27:10 p1018) measures performance for a systems software instruction mix. The results are without register variables. With register variables, Manx, Microsoft, and Mark Williams run proportionately faster, Lattice and Computer Innovations show no improvement.

	Execution Time	Code Size	Compile/ Link Time
Dhrystone Benchmark			
Manx Aztec C86 3.3	34 secs	5,760	93 secs
Microsoft C 3.0	34 secs	7,146	119 secs
Optimized C86 2.20J	53 secs	11,009	172 secs
Mark Williams 2.0	56 secs	12,980	113 secs
Lattice 2.14	89 secs	20,404	117 secs

Great Features: Manx Aztec C86 is bundled with a powerful array of well documented productivity tools, library routines and features.

Optimized C compiler	Symbolic Debugger
AS86 Macro Assembler	LN86 Overlay Linker
80186/80286 Support	Librarian
8087/80287 Sensing Lib	Profiler
Extensive UNIX Library	DOS, Screen, & Graphics Lib
Large Memory Model	Intel Object Option
Z (vi) Source Editor -c	CP/M-86 Library -c
ROM Support Package -c	INTEL HEX Utility -c
Library Source Code -c	Mixed memory models -c
MAKE, DIFF, and GREP -c	Source Debugger -c
One year of updates -c	CP/M-86 Library -c

Manx offers two commercial development systems, Aztec C86-c and Aztec C86-d. Items marked -c are special features of the Aztec C86-c system.

Aztec C86-c Commercial System	**$499**
Aztec C86-d Developer's System	**$299**
Aztec C86-p Personal System	**$199**
Aztec C86-a Apprentice System	**$49**

All systems are upgradable by paying the difference in price plus $10.

Third Party Software: There are a number of high quality support packages for Manx Aztec C86 for screen management, graphics, database management, and software development.

C-tree $395	**Greenleaf $185**
PHACT $250	**PC-lint $98**
HALO $250	**Amber Windows $59**
PRE-C $395	**Windows for C $195**
WindScreen $149	**FirsTime $295**
SunScreen $99	**C Util Lib $185**
PANEL $295	**Plink-86 $395**

MACINTOSH, AMIGA, XENIX, CP/M-68K, 68k ROM

Manx Aztec C68k

"Library handling is very flexible . . . documentation is excellent . . . the shell a pleasure to work in . . . blows away the competition for pure compile speed . . . an excellent effort."

Computer Language review, April 1985

Aztec C68k is the most widely used commercial C compiler for the Macintosh. Its quality, performance, and completeness place Manx Aztec C68k in a position beyond comparison. It is available in several upgradable versions.

Optimized C	Creates Clickable Applications
Macro Assembler	Mouse Enhanced SHELL
Overlay Linker	Easy Access to Mac Toolbox
Resource Compiler	UNIX Library Functions
Debuggers	Terminal Emulator (Source)
Librarian	Clear Detailed Documentation
Source Editor	C-Stuff Library
MacRam Disk -c	UniTools (vi,make,diff,grep) -c
Library Source -c	One Year of Updates -c

Items marked -c are available only in the Manx Aztec C86-c system. Other features are in both the Aztec C86-d and Aztec C86-c systems.

Aztec C68k-c Commercial System	**$499**
Aztec C68d-d Developer's System	**$299**
Aztec C68k-p Personal System	**$199**
C-tree database (source)	**$399**
AMIGA, CP/M-68k, 68k UNIX	**call**

Apple II, Commodore, 65xx, 65C02 ROM

Manx Aztec C65

"The AZTEC C system is one of the finest software packages I have seen"

NIBBLE review, July 1984

A vast amount of business, consumer, and educational software is implemented in Manx Aztec C65. The quality and comprehensiveness of this system is competitive with 16 bit C systems. The system includes a full optimized C compiler, 6502 assembler, linkage editor, UNIX library, screen and graphics libraries, shell, and much more. The Apple II version runs under DOS 3.3, and ProDOS, Cross versions are available.

The Aztec C65-c/128 Commodore system runs under the C128 CP/M environment and generates programs for the C64, C128, and CP/M environments. Call for prices and availability of Apprentice, Personal and Developer versions for the Commodore 64 and 128 machines.

Aztec C65-c ProDOS & DOS 3.3	**$399**
Aztec C65-d Apple DOS 3.3	**$199**
Aztec C65-p Apple Personal system	**$99**
Aztec C65-a for learning C	**$49**
Aztec C65-c/128 C64, C128, CP/M	**$399**

Distribution of Manx Aztec C

In the USA, Manx Software Systems is the sole and exclusive distributor of Aztec C. Any telephone or mail order sales other than through Manx are unauthorized.

Manx Cross Development Systems

Cross developed programs are edited, compiled, assembled, and linked on one machine (the HOST) and transferred to another machine (the TARGET) for execution. This method is useful where the target machine is slower or more limited than the HOST, Manx cross compilers are used heavily to develop software for business, consumer, scientific, industrial, research, and educational applications.

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LETTERS

DOBB'S POST 2 CENTS 2

Not for Profit?

Dear *DDJ*,

Your most recent name change has brought into focus a matter which has been irritating me for some time: The copyright declaration stating that published programs are for "personal use only, not for profit." Your "Software Tools" are now said to be "for the professional programmer." Most professional programmers, in my experience, are in the business for profit (or at least to keep food on the table). Given the confusing (at least to me) state of litigation concerning software protection, even to the extent of reverse engineering now apparently illegal, I find myself wondering if I dare read any magazines for fear that I might unconsciously use a line of someone else's code for profit. I am particularly irritated when I note that the code in question has been copied largely from another source. K & R seems to be a rich source of freshly copyrighted material, for example.

A specific example which I found recently: An "author" took the code for GREP.C distributed by DEC, added *#defines* so that it would compile under another compiler, and copyrighted it as "not for profit," "cannot modify or distribute," and so on. Does this mean DEC can't use it anymore?

I would like to see further discussion of program protection and publication matters in *DDJ*. In the meantime, could you persuade some of your authors to state "portions may be used in applications providing suitable credit is given" or something to that effect?

Allen R. Balmer
6845 West Henrietta Rd.
Rush, NY 14543

DDJ has always been in favor of public-domain software; unfortunately, the line between public-domain and copyrighted code has become increasingly blurred. Even the laws seem a little confused at times. When a software author modifies a public-domain program and releases the modified version, is he or she entitled to copyright it? Does it depend on the amount and nature of the modifications made? We welcome your point of view.—ed.

Who is DDJ For?

Dear *DDJ*,

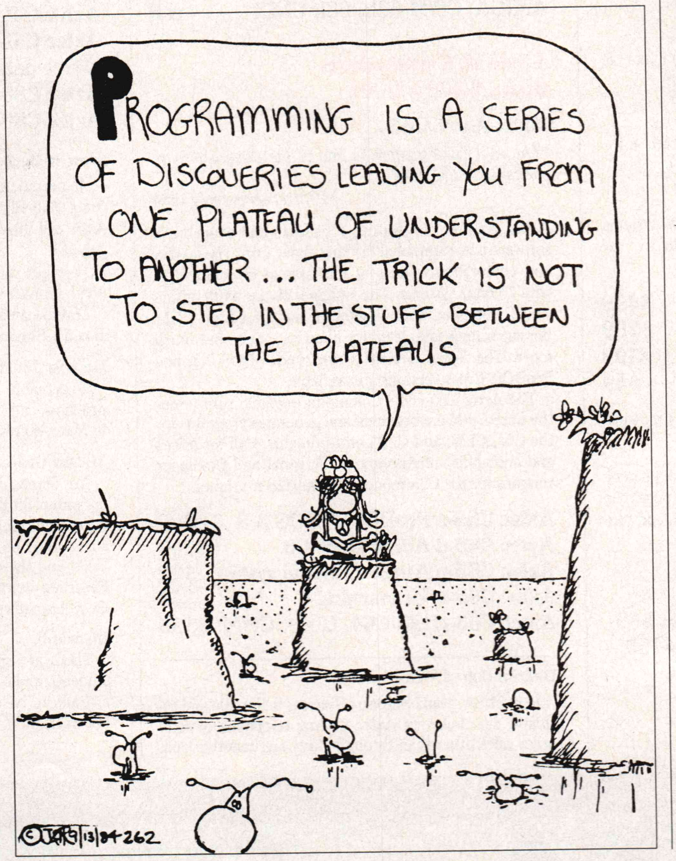
When I subscribed to *DDJ* three years ago, the magazine was described as "for users of small computer systems." A year later (March 1984), it became "for the experienced in microcomputing." Two months after that it became ". . . for advanced programmers." Now you are ". . .for the professional programmer." It seems that you are becoming "for" a smaller and smaller readership.

By some stretch of imagination I might still be considered eligible to be a subscriber, but your next redefinition will surely exclude me. But it probably won't matter, for by that time *DDJ* will likely be merely an index of what's available on your bulletin board.

Why not just publish the magazine and let the individual decide if the magazine is for him?

Dave Sullivan
207 Maclane St.
Palo Alto, CA 94306

As the market for computer magazines grows larger and more confusing, it becomes increasingly important for each magazine to carefully target its audience. DDJ's audience has always been a very devoted and well-defined group of people, and we'd like to stay focused on that group. This means that people who are looking for introductory articles on programming in BASIC or who need to learn how to use their new spreadsheet will have to look elsewhere. But it's also important not to get too carried away. We think Mr. Sullivan has a point. What do you think?—ed.

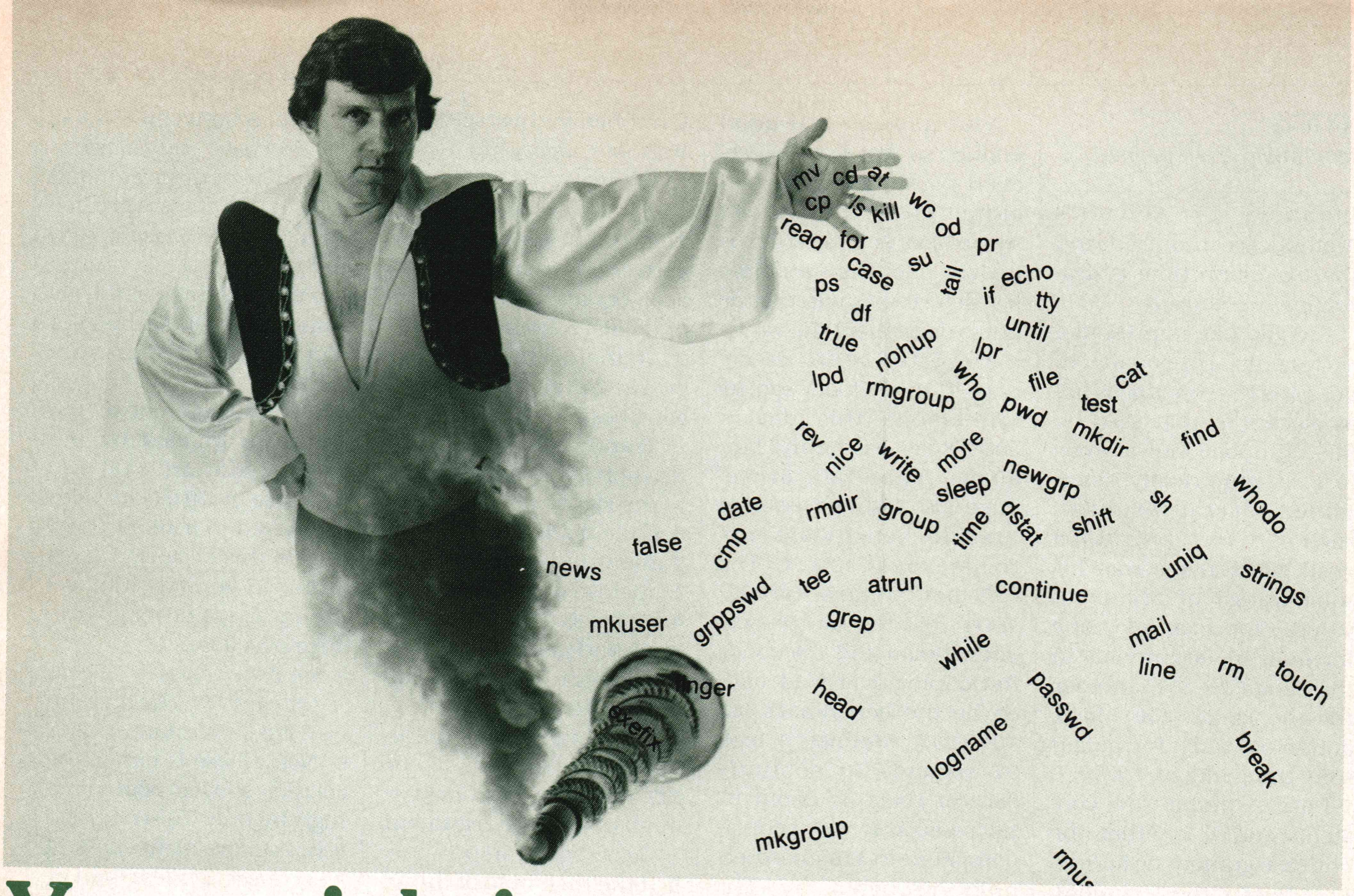


Right to Assemble

Dear *DDJ*,

Mr. Campbell's The Right to Assemble column (March 1986) on computing integer square roots presents a clever modification of Newton's Method that is considerably more efficient than previous implementations that have appeared in the pages of *DDJ* and other magazines.

The essence of Newton's Method is to guess the value of the root and then to compute successively better guesses, using a simple formula, until the desired accuracy has been achieved. Mr. Campbell uses an ingenious scheme to arrive at a good initial guess. As a result, very few



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LETTERS
(continued from page 8)

iterations of Newton's Method are required and the execution time is dramatically reduced.

I would like to present a different approach to guessing the root that is not as elegant as that used by Mr. Campbell but is even faster. I empirically determined several formulas, each of which provides a good guess at the root for some range of argument values (for example, one formula for arguments in the range 2–255, another for the range 256–4095, and so on). Each formula is something like $(A * X) + B$ where A and B are constants and X is either the entire argument or just the high byte of the argument.

The guesses are good enough so that a single iteration of Newton's Method either gives the correct square root or a value that is high by one. Then, a simple test determines whether or not to decrement the value.

The *CALC_ROOT* procedure (Listing One, page 60) implements this idea in 8088/8086 assembly language. The *TIME* procedure (also Listing One) was used to benchmark my routine on an IBM PC. The full benchmark (*TIME_ROOT* routine) ran 98 seconds. Deducting 7 seconds for looping overhead, added by the benchmark (*TIME_OVER* routine), it took 91 seconds to compute 983,040 roots or about 92 microseconds per root as compared to 183 microseconds reported by Mr. Campbell for his 16032 routine. My algorithm works as follows:

1. If the argument equals zero or one then the square root equals the argument and I just return its value.
2. If the argument is between 2 and 255 inclusive, set *Guess = Argument/16 + 3* and go to Step 7. The division by 16 is a 4-bit shift to the right.
3. If the high byte of the argument is between 1 and 15 inclusive, set *Guess = 4 ** (high byte of the argument) *+ 13* and go to Step 7. The multiplication is a shift left of two bits.
4. If the high byte of the argument is between 16 and 127 inclusive, set *Guess =* (high byte of the argument) *+ 50* and go to Step 7.
5. If the high byte of the argument is between 128 and 254 inclusive, set *Guess =* (high byte of the argument) *+ 40*. If this guess is greater than 255, set *Guess = 255* and go to Step 7.
6. If the high byte of the argument equals 255 then the root is 255 and I return that value.
7. Get the quotient of the argument divided by the guess. I use an 8-bit *DIV* which saves 70 clock cycles compared to a 16-bit *DIV*. I can do this because I have excluded (in Step 6 above) the one case that could produce overflow.
8. Set *New Guess = (Guess + Quotient)/2*. The division by 2 is a 1-bit rotate.
9. *New Guess* is either the correct square root or is high by one. To see which it is, I square *New Guess*. If *New Guess ^2* is less than or

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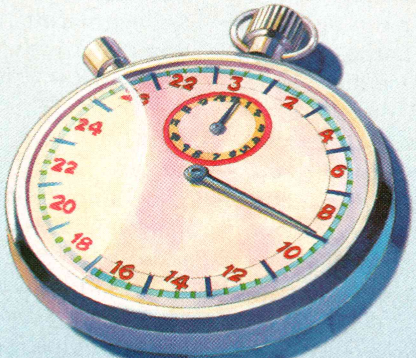

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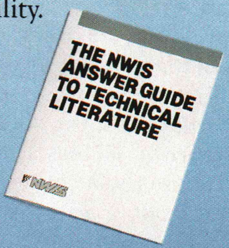

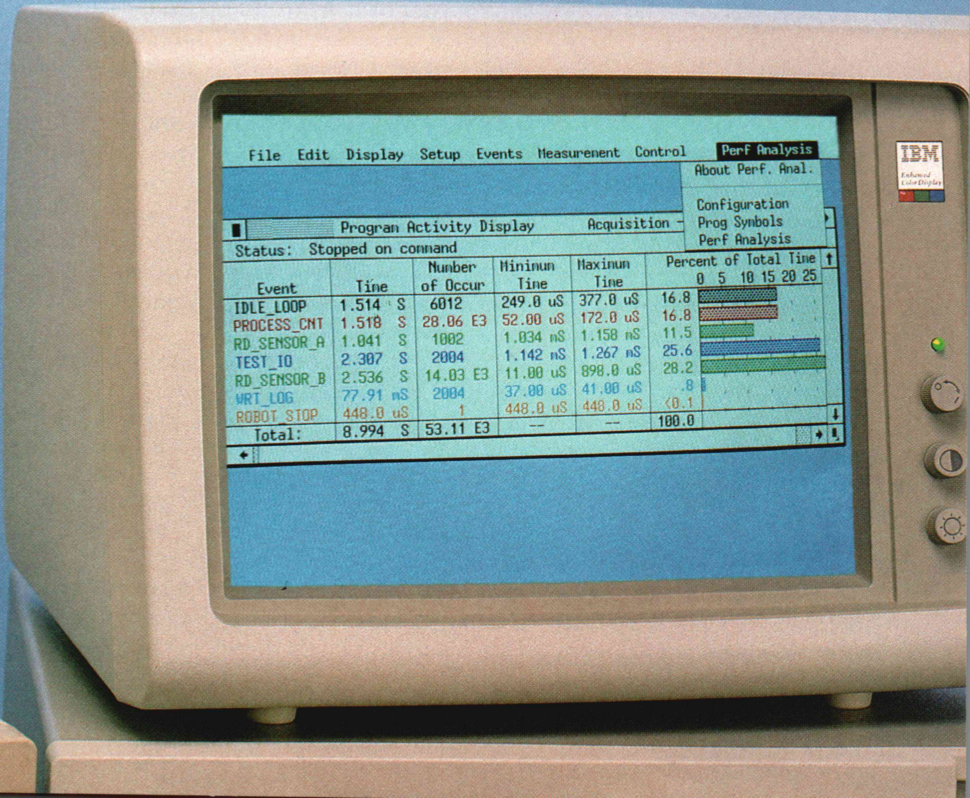

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(continued from page 10)

equal to the argument, then the square root equals *New Guess* or else it equals *New Guess* − 1.

This method is an example of perspirational rather than inspirational programming. I wrote a small BASIC program (Listing Two, page 62) designed to test out different formulas. After some tedious hours trying various possibilities I found a set of ranges and formulas that worked.

My BASIC program is quite fast because it only tests argument values that are one less than a perfect square (for example, numbers of the form N^2 − 1). These tend to be the worst case situations because the exact root of such numbers is very near to N while the integer root is $N - 1$.

The *TEST* procedure (Listing One) was used to verify the accuracy of the root for all 65536 argument values. In this test, I checked that the square of the root is less than or equal to the argument and that *(root + 1)*^2 is greater than the argument.

Robert Pirko
211 West 56th St.
Apt. 36L
New York, NY 10019

Dear *DDJ*,
I noticed The Right to Assemble column discussing integer square roots as implemented on the 68000 and the 32000 in the March 1986 issue. I wish to further illustrate the advantage of using the higher-level instructions of the 32000 with a listing of my routine to perform a floating-point square root in software. It uses a format similar to IEEE double precision, except that I put the exponent on the right to reduce the number of operations required. My 16032 with a 7.16-MHz clock takes 190 microseconds to do the double-precision square root (including variable passing overhead). This is 1,113 times faster than BASCOM does it on my Z80 system (3.68 MHz, 1 wait state). Because I don't have access to a 68000 computer, I don't know how it would fare in this task.

In Listing Three, page 62, you will notice there is no looping and there are no calls to the floating-point multiply or divide routines. The algorithm used is called Newton's Method and iteratively executes the following equation:

Y = Y/2 + (X/2)/Y

The equation is based upon the use of a derivative to extrapolate and calculate a more precise guess. The binary exponent is a great aid in choosing the first guess. We know to start with that the mantissa of the answer will be between 1 and 2; furthermore, the even-or-odd condition of the original exponent tells us if the mantissa of the answer will be above or below the square root of 2. With this guidance, we make the first guess either 1.189 or 1.68. This is enough of a start so that four iterations is always enough to obtain the required 53 bits of precision. Only in rare cases would three iterations be enough, so we always do four iterations without any testing. Because the precision of the result more than doubles with each iteration, the first three iterations can be performed with less precision, and the compactness of the 32000 instructions makes it easy to take advantage of this fact. Notice in the listing, starting at label *SQR2*, how easy it is to do the first three iterations with 32-bit precision on the 2000. The *DEID* R3,R4 instruction takes a 64-bit value in R4R5 and divides it by the 32-bit value in R3. It puts the quotient in R5 and the remainder in R4. Four machine-code instructions to evaluate the whole equation is what I would call efficient.

Neil R. Koozer
Kellogg Star Rt.
Box 125
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James R. Nichols,
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P.O. Box 374
Spicer, MN 56288

Corrections

Dear *DDJ*,
Thank you for including our software in the March 1986 issue of *DDJ*. There is a slight error in that paragraph which depreciates the value of our hardware. It should read ". . . LAB 40 is a structured parallel port that takes 16 memory or I/O locations . . ."

The article has it reading 16K (the K should be omitted).

Scott Vanderlip
75 Southgate Ave.
Suite 6
Daly City, CA 94015

Dear *DDJ*,
By this time you have undoubtedly caught the errors in The Right to Assemble column in March 1986.

The worst error is the definition of the (integer) square root of an integer, at the top of column 2. By your definition, the square root of 17 (or of any prime number) would be 1.

The others, at the top of column 3, lead you to say in one sentence that "4 is not the correct root" and in the next that "the integer square root of 24 is 4." In the same sentence, you have "24 divided by 4 equals 5."

Dorothy Wolfe
245 Hathaway Ln.
Synnewood, PA 19096

Dear *DDJ*,
Thank you for your excerpt on our company in your January (1986) Of Interest column.

We would like to point out that you mentioned our company name as ATC International in your column when actually it should have been ACS International.

Janet M. Heidenreich
Advanced Computer
Solutions International
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DDJ

(Listings begin on page 60.)

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DDJ ON LINE

For those of you who missed it the first time, here is how to log on to the DDJ Forum.

1. Get yourself a CompuServe account. (Call CompuServe at (800) 848-8199 for information.)
2. Log on to CompuServe and type go ddj at the prompt. This will bring you into the Display Area, the Read Only (noninteractive) module of the SIG. Here you'll find information about the DDJ Forum.
3. Select the last menu choice from the Display Area Menu. This will bring you into the Forum where the message boards, Data Libraries, and real-time conferencing features are. That's also where you'll find me and columnists such as Mike Ham, Namir Shammas, Ray Duncan, and Allen Holub.
4. Type I at the Top Menu. This will give you a list of commands and a thumbnail sketch of the Forum's structure and features. You should capture this list and print it out. It's handy to use as a map until you acquaint yourself with the territory.
5. Read the bulletins and help files. Type B at the Top Menu to read the bulletins. These provide more information about various aspects of the Forum. I also recommend that you go to DL0 (type DL0 at the Top Menu) and browse the help files there. To do this, type BRO at the DL menu. When it asks you for KEYWORDS, type HELP. The best help file for a quick start is EZSIG HELP.

*That should get you started folks. Of course the only real way to learn how the system works is to work on the system <grin>. Try things out, make a few mistakes, get the feel of it. And if all else fails, ask that *SYSOP person—she'll be glad to help.*

*—Levi Thomas (*SYSOP)*

The following is an on-line exchange that took place in the Forum's House of ALGOL (the on-line version of Namir Shammas' Structured Programming columns).

Modula-2

11-Mar-86
Sb: Modula-2 Tools
Fm: Bill 73047,2624
To: All
I am just getting started in Modula-2 although I have programmed in just about everything else. I am writing a simple multitasking dispatcher for a fun project I'm developing. When I get it to where I like it, I'll let you know if you're interested. I suspect that I'm reinventing the wheel, but I haven't been able to find anything like it in the public arena.

12-Mar-86
Sb: Modula-2 Tools
Fm: Bob 76703,532
To: Bill
I assume you are aware of MODUS, the Modula-2 User Group? If not, I'll gladly provide you with an address. Check out recent issues of ACM *SIGPlan Notices*. (It should be available at most libraries.)

The June 1985 issue contains two Modula-2 articles. One of them, entitled "Two Approaches to Implementing Generic Data Structures in Modula-2," is by Weiner and Sincovec, the gentlemen with a reasonable Modula-2 book to their credit.

The December 1985 issue contains three articles relating to Modula-2, including one from a user of both Modula-2 and Ada.

The articles you will be most interested in are entitled "Modula-2 Process Facilities" and "Modula-2 and the Monitor Concept." These are by D. A. Swery and are in the November 1984 issue. Both articles are reasonably well written and both contain source code. The first article extend's Dr. Wirth's binary semaphores to counting semaphores, and the second is a Modula-2 implementation of Hoare's monitor concept. That both semaphores and monitors can easily be implemented in Modula-2 (without resorting to assembly) is an excellent example of the power of Modula-2's coroutines.

The October 1984 issue has an article about implementing semaphores under Unix without kernel changes. Some code (in C) is included as examples. This article is of interest because it makes minimal assumptions about the underlying OS.

The January 1986 issue contains an article entitled "Detection of Deadlocks in Multiprocess Systems," which should be of interest to people designing tasking systems.

13-Mar-86
Sb: Modula-2 Tools
Fm: Bill
To: Bob
Thanks much for the info. I'll check in the company library for the *SIGPlan Notices*. Could you please give me the address for MODUS? I'm afraid I'm a Pascal bigot and ignorant of the Modula-2 user community. I'm rapidly converting! Would there be a more definite way of asking for the SIGPlan info? Sometimes the library isn't too sure of the really technical stuff. Thanks again!

14-Mar-86
Sb: Modula-2 Tools
Fm: Bob
To: Bill
The address of MODUS is
MODUS
c/o George Symons
P.O. Box 51778
Palo Alto, CA 94303
(415) 322-0547
Dues are $20/academic year. The basic benefit is four newsletters/year. The membership form asks for name, company (if appropriate), address, phone, electronic address, and which implementations of Modula-2 you use. In addition there are three options:

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2. Print only my name and country in any rosters.
3. Don't release my name on any mailing lists.

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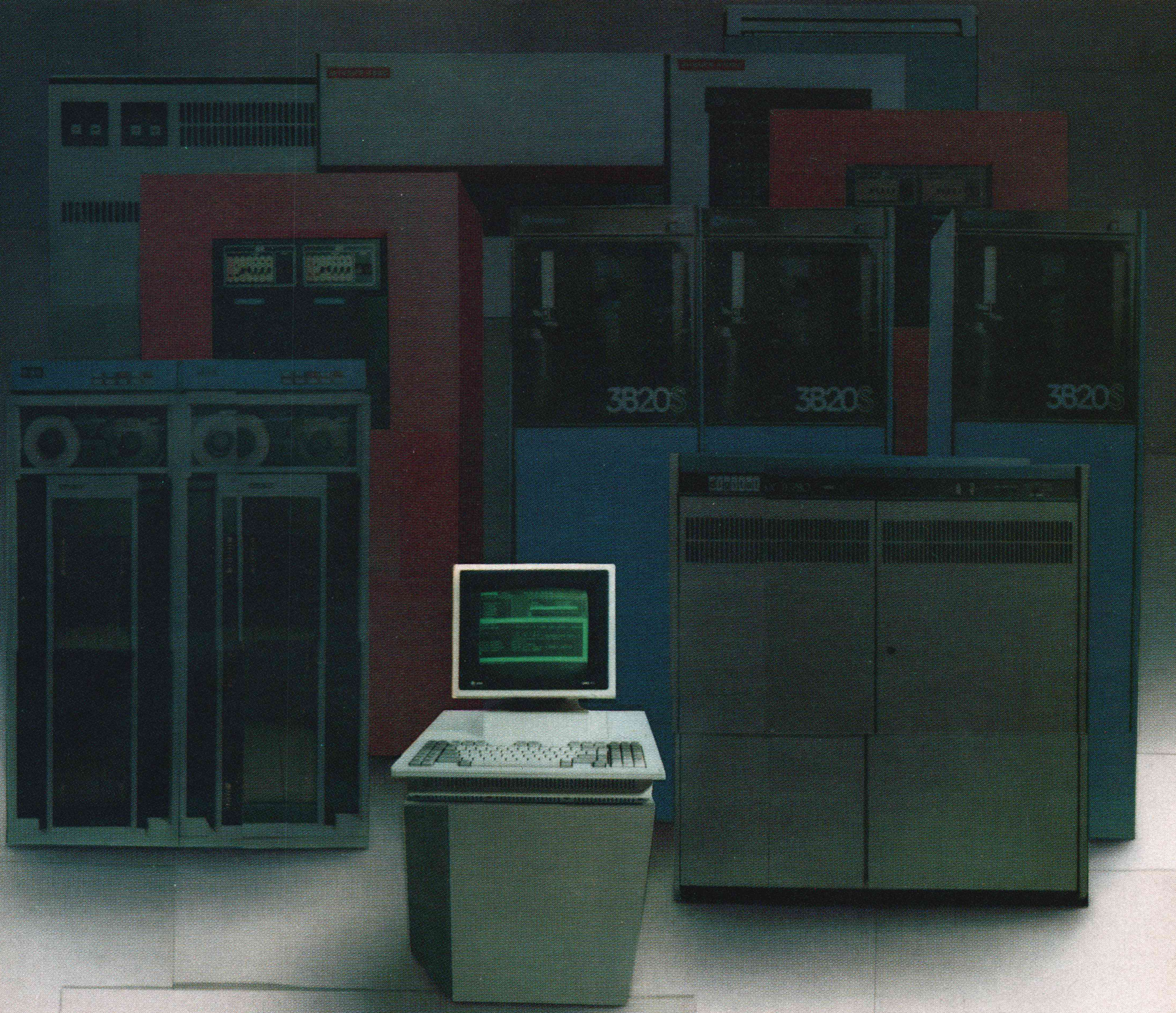
Your librarian should be able to look up the *SIGPlan Notices* issues using the dates given. *SIGPlan Notices* is the actual name of the magazine. It is a monthly publication of ACM's (Association for Computing Machinery) Special Interest Group for Programming Languages.

If your company library doesn't have *SIGPlan Notices*, many public libraries have it. It really is quite common.

20-Mar-86
Sb: Logitech's Modula-2
Fm: Bill
To: Bob
I've just acquired Logitech's Modula-2. I had the ITC (still



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DDJ ON LINE
(continued from page 14)

have it, actually) and found it much too buggy. So far the only problem I've found with Logitech is that I didn't go for the "sources" right off. But . . . that's for when the checkbook gets back to a plus balance I guess. On a similar subject, what are all the Modula-2 folks reading out there? I just ordered the Wirth third edition from the publisher, but I suspect that other good Modula-2 books are available. I have the "Shipbuilder's" book but found it to be much too low a level. As a lifetime systems programmer, I need meat to keep me happy—none of this "cute" stuff. (Do "real systems programmers" read "cute"?) I noticed that McGraw-Hill (in the CServe electronic mail) had Olglvie(sp?)'s book for sale. Is it any good? Any other suggestions?

19-Mar-86
Sb: Turbo Multitasking
Fm: Jean 76606,671
To: Sysop—All
Hi! I bought my first *DDJ* last week (never too late. . .). I found the paper about multitasking with Turbo-Pascal very interesting. I looked for an IBM XT version in your DLs. Can I expect to see it one of these days? I'm a new IBM user (I'm more used to Apple-Pascal) and I didn't find all addresses to drive the modem. Also, does someone here know if Logitech's Modula-2/86 Version 2.0 compiler (the one announced for $89) supports all Modula-2 features (especially coprocessing)?

19-Mar-86
Sb: Logitech's Modula-2
Fm: Steve 70003,1326
To: Jean
Yes, it is all there. I have been working with Logitech's Modula-2 for about a month now. It is for real, a production compiler. I have it running on my DEC Rainbow (the editor is only for the IBM PC). I have already written a simple terminal program in Modula-2. I have no problem getting to INTs and interrupt vectors.

20-Mar-86
Sb: Logitech's Modula-2
Fm: Bob
To: Jean
Yes! Logitech's Modula-2/86 does support the entire language, including coroutines, *TRANSFER*, and *IOTRANSFER*. (*IOTRANSFER* implies being able to write interrupt handlers in Modula-2, which can in fact be done using Logitech's compiler.)

Logitech's Modula-2/86 is probably the best Modula-2 for the IBM PC, clones, and the 8086 in general.

21-Mar-86
Sb: Logitech's Modula-2
Fm: Bill
To: Jean
I have the debuggers—Post and Runtime. Both are unreal and well worth every cent. I, too, forewent the "sources" and will order them as soon as the checkbook recovers from all the other things I have gotten in the last few weeks. Although you don't "need" them to run the compiler, they would be nice as it is through the sources that you can customize the compiler/editor/linker options. It would also be nice to see the internals of some of the library modules. (I am, alas, a "real" systems programmer and not seeing the real code deprives me of my satisfaction.) I hope that this forum on Modula-2 gets going as I am just learning this language (it's probably number 20 or so) and it's the best so far. Now, if somebody will just point me to an Ada compiler environment for the PC, I'll move on (hee, hee). . . . You must understand, I dearly love my "toys" (got it from my father) and technical stuff gets me high.

20-Mar-86
Sb: Logitech's Modula-2
Fm: Jean
To: Steve
Thanks to Steve, Bob, and Bill for your answers! Great feedback in this SIG! So, think I'm gonna order that Modula-2. An IBM SW user suggested I buy the Utility package (for Postmortem debugger) and Sources features. Sources are expensive . . . I don't know. . . so I'm happy to find help. I'll make my first steps in that great language, the normal step after Pascal. So, thanks again! Jean (ps: Are you all "real system programmers"?—I am an amateur programmer!)

DDJ

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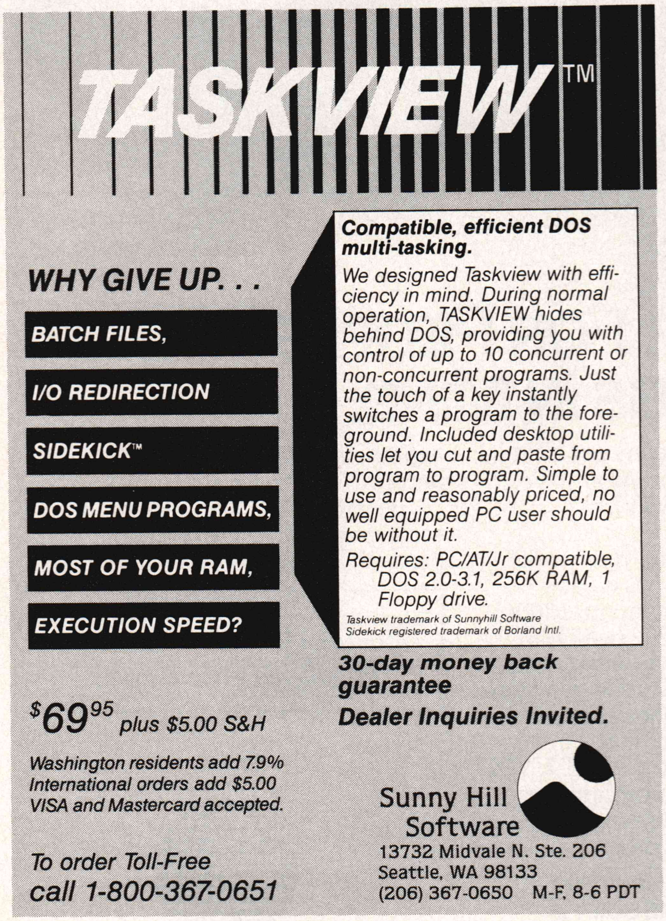

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Trees and More on Microsoft and Lattice Compilers

My main topics this month are binary trees and C compilers. I'll look at a couple of fancy tree-printing routines and at a nonrecursive tree-traversal routine. Before leaping into trees, though:

A New Version of the Shell

DDJ is now shipping a new version of the shell that originally appeared in this column. In addition to fixing all the bugs I know about, I've included several significant enhancements in the new version. Pipes are now supported (you can even put the pipe temporary files on a RAM disk if you want). The *alias* and *history* expansion routines have also been improved considerably. You can now say:

```
a foo echo foo
a bar echo bar
a foobar 'foo;bar'
```

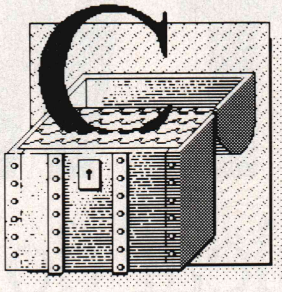
as well as:

```
!! >bar; !pat
```

DOS-compatible prompt support has been added (*$t*, *$d*, *$e*, and so on). You can change the escape character from backslash to another character so you can use backslash as a path separator. *Exit* takes a value so that a batch file that was called as a subroutine from another batch file can return a value to the calling process. *$status* is supported (it works a bit like *errorlevel* does).

by Allen Holub

Most important, all the C shell control flow commands (except *goto*) are now supported. In particular, there is an *IF . . . THEN . . . ELSE* mechanism, *WHILE* and *FOREACH* loops, and a C-like *SWITCH* statement. Complicated expression analysis is supported in these statements, using several operators (( ), +, −, *, /, %, <=, >=, <, >,



!=, ==, !, &&, and | |). You can create and modify variables (with an @ command). In short, you can now actually write real shell scripts.

Upgrades from Version 1 are available from *DDJ* for $6.

Printing a Tree

Ever since I was an undergraduate, I've wanted to write a routine that printed binary trees graphically—that drew a picture of the tree, showing with dashes and arrows where all the pointers went and which nodes were where. So this month, I finally sat down and did it. In fact I did it twice—once for an in-order traversal and once for a preorder traversal. Output from the tree-printing routines is shown in Figures 1 and 2, page 19.

The tree-printing routines are in Listing One, page 68. The *sinorder( )* function (lines 70−94) is included to show how the basic algorithm works. The static variable *depth* keeps track of the depth of the current node in the tree. The root is at depth 0, its children are at depth 1, and so on. The subroutine does an in-order traversal in the normal way. Instead of just printing each node, however, it prints *depth* tabs and then prints the node. This way, the farther down a node is in the tree, the farther to the right it will appear on the page.

A sample output is shown in Figure 3, page 19. There are two problems here. First, because there are no connecting lines, it's a little hard to see the internal connections in the tree. Second, a mirror image of the tree has been printed. Because a normal in-order traversal looks like:

```
traverse( root )
{
    traverse (left)
    print the root
    traverse (right)
}
```

the leftmost node of the left subtree will be printed first. A glance at Table 3 shows that the output is backward—the leftmost node ends up on the far right.

Both these problems are corrected in the subroutine *inorder* (lines 120−156). Fixing the mirror-image problem is easy. You just change the traversal algorithm to:

```
traverse( root )
{
    traverse (right)
    print the root
    traverse (left)
}
```

Getting the lines is a little more difficult. The problem is the vertical lines (printed with | characters). A bit map is kept in which each bit corresponds to a particular depth in the tree. If a bit is set, then a | is printed when you arrive at the equivalent depth in the output. So, all you need to do is set and clear these bits at the appropriate time. The relationships between the bit map and the final picture are illustrated in Figure 4, page 19.

If you set and clear the bits in the simplest possible way (that is, set the bit on line 131 of Listing One and clear it on line 153), a picture such as:

```
    |       +---g
    +---f---+
    |       +---e
d---+
    |       +---c
    +---b---+
    |       +---a
```

is created. You can avoid the topmost line by adding horizontal lines as you ascend rather than descend the tree. That is, the horizontal line for node *f* won't be added until after you've processed node *g*. This is done in the code on line 147 by setting the bit for the current level after a node has been printed. Setting the next level if there is no right child (line 135) avoids problems such as:

```
    +---g---+
    |           +---f
    |       +---e---+
d---+
```

and

```
f---+
            +---e
    +---d---+
```

where a line is omitted.

There are two situations in which a bottom extraneous line is created:

```
            +---i
    +---h---+
g---+
|   |       |   +---f
    |       +---e---+
    +---d---+
    |       +---b
```

To get rid of the extraneous line to the left of the *b*, you need to know whether the current node is a left or right child. You can then clear the appropriate bit when you process a left child. In the above example, if node *d* knows that it's a left child, it can clear the bit at its own depth before descending. This way the extra line isn't printed to the left of the *b*. The variable *amleft* indicates whether the current node is a left or right descendant. It should be set to 0 the first time *inorder( )* is called.

The second extra line (to the left of the *f*) is actually left over from processing node *i*. Because there was no left child, the test I just described wasn't performed. This situation is addressed by the code on lines 149—152. If there's no left descendant for the current node, you'll always clear the bit at *depth+1*. In the above example, because node *h* has no left descendant, it will clear the extra bit before ascending. The problem of no right child is addressed on lines 132—135.

The *preorder( )* routine (lines 172—203) uses more or less the same process. A new problem pops up here. You need to print an occasional blank line so that the output doesn't

```
                    +---O
            +---N---+
            |       +---M
    +---L---+
    |       |       +---K
    |       +---J---+
    |               +---I
H---+
    |               +---G
    |       +---F---+
    |       |       +---E
    +---D---+
            |       +---C
            +---B---+
                    +---A

H
+-------D
|       +-------B
|       |       +-------A
|       |       +-------C
|       +-------F
|               +-------E
|               +-------G
|
+-------L
        +-------J
        |       +-------I
        |       +-------K
        |
        +-------N
                +-------M
                +-------O
```

Figure 1: *Printing a balanced tree*

```
                    +---N
            +---M---+
    +---L---+
    |       |       +---K
    |       +---J---+
    |               +---I
H---+
    |               +---G
    |       +---F---+
    |       |       |       +---E
    |       |       +---D---+
    |       |               +---C
    +---B---+
            +---A

H
+-------B
|       +-------A
|       +-------F
|               +-------D
|               |       +-------C
|               |       +-------E
|               |
|               +-------G
|
+-------L
        +-------J
        |       +-------I
        |       +-------K
        |
        +-------M
                +-------N
```

Figure 2: *Printing an unbalanced tree*

look like the following example:

```
d
+-------b
|       +-------a
|       +-------c
+-------f
        +-------e
        +-------g
```

(there should be a blank line above the *f* node). The code to do this is on lines 195—199. A blank line is printed if the current node is a right descendant and has no children. In the above example, this will happen at nodes *c* and *g*. The mirror-image issue is not a problem in a preorder traversal because you usually want to read down the columns (as in the above example). If you applied the same mirror-image reversal to the preorder traversal that you used in the in-order traversal, nodes *a* and *c* (and nodes *e* and *g*) would be transposed incorrectly.

The bit-map routines (*setbit( ), testbit( )*, and *makebitmap( )*) originally appeared in this column more than a

```
                              A
                    B
          D                   C

                              E
                    F
H                             G

                              I
                    J
          L                   K

                              M
                    N
                              O
```

Figure 3: *Output from* sinorder( )

```
Lines at this level correspond to this
bit in the map:

                Bit 1   Bit 2   Bit 3
                  .       .       .
                  .       .       +--- R
                  .       +---P---+
                  .       |   .   +--- O
                  +---N---+   .       .
                  |       .   +---M    .
              L---+   .               .
              .   |           +---K
                .                     .
              .   +---J---+   .       .
              .       .   +---I       .
              .       .       .       .
Node is
at depth:     0       1       2       3
```

Figure 4: *Relationships between bits and lines*

(continued from page 20)

year ago. They're reproduced in Listing Two, page 71.

Nonrecursive Tree Traversal

One of the problems with most traversal algorithms is that they're recursive. If a tree degrades to a linked list, you'll need as many recursion levels as there are nodes in the tree. Each recursion level requires its own stack frame, so assuming a 10-byte stack frame, you'll need 1,000 bytes of stack to traverse a degraded, 100-node tree. This can cause problems if huge amounts of stack aren't available, so occasionally it's useful to give up the simplicity of a recursive algorithm for an iterative one.

It's easy to search for a node or insert a node into a tree in a nonrecursive way because you never have to remember where you came from. That is, you only have to descend to the proper node and never have to go back up again. A nonrecursive search-and-insert function is given on lines 30–66 of Listing One.

Nonrecursive traversal is a harder problem because you have to go backward. In a recursive traversal routine, the pointer to the previous node is stored on the run-time stack, as part of the current subroutine's stack frame. That is, the pointer to the current node is passed to a recursive subroutine as a parameter. That parameter won't be modified by subsequent recursive calls because it's stored on the stack by each successive recursive call.

In an iterative traversal, you don't have the luxury of a run-time stack. One solution to this problem is to maintain your own stack of pointers to previous nodes as a static data structure, thereby moving the previous-node information from the run-time stack to the static data area. This method wastes space, though, because you already have a convenient place to store the previous-node pointers—in the tree itself. As you descend the tree, you can reverse the pointer that you just used to get to the current node so that it now points back up to the previous node. As you ascend back up, you reverse the pointer again. The basic traversal algorithm is shown in Table 1, below.

Deciding in which direction to go when you're at any given node is a problem. You'll go through every node three times— once on the way down, once again as you ascend from the left, and a third time as you ascend from the right. The problem is resolved by "marking" a node after you've printed the left subtree but before you descend right (that is, the second time you visit it). This way, when you come back up from the right, you can look at the mark and decide to ascend rather than go right again. Only one bit is needed to mark a node, so because my nodes have an ASCII string as one of their fields, I set the high bit of the first character in the string to mark a node. Macros to set, clear, and test this bit are on lines 23–25 of Listing One. If an extra bit isn't available, you can always add a tag field to the *LEAF* structure, but it seemed like a waste of memory to do that here.

The routine *lr_trav( )* (on lines 245–301 of Listing One) is a straightforward implementation of the algorithm in Table 4. It does an in-order traversal. Comments are inserted in the code to show where preorder or postorder visits should go (remove the in-order visits in these cases). The *pres* variable points at the node currently being visited. The *prev* variable points at the present node's parent. *Next* is just a convenient place to put things as you reverse pointers.

There are other nonrecursive traversal algorithms (the most interesting is the Robson traversal, which doesn't need to mark nodes), but they're all more complicated to implement than a simple link-reversal algorithm. If you're interested in these other methods, look at Thomas A. Standish's book *Data Structure Techniques* (Reading, Mass.: Addison-Wesley, 1980), 74–83.

```
do forever
    if( present node is marked )
        Clear mark.
    else
        while( there's a left child )
            Visit present node if doing preorder traversal.
            Go left.
        Visit pres node if in-order or preorder traversal.
    Visit present node if postorder traversal.
    if( no previous node )
        break
    if( previous node is marked )
        Go up from a right child.
    else
        Go up from a left child.
        Visit present node if in-order traversal.
        Mark the present node.
        Go right.
```

Table 1: *A link-reversal tree-traversal algorithm*

Microsoft C, Version 3.0

To no one's surprise, I received a call from Microsoft soon after my review of its compiler was published in the March 1986 C Chest. The company was (perhaps justifiably) miffed, so I agreed to give it equal time in the column—fair is fair. Sandra Jacobson (product manager, Systems Languages) at Microsoft sent me the following letter in response to that review:

"We appreciate Allen Holub's comments regarding the Microsoft C compiler. We try to improve each version of the compiler through comments and recommendations from users and reviewers.

"Although we agree with many of the comments made by Allen, as they have also been recommended to us by other users of Microsoft C, we still disagree with some major points. The following comments and recommendations have been incorporated into Version 4.0 of the compiler:

1. We have improved the internal error messages that are displayed. We have also improved on the error recovery in the parser.
2. The command-line interface has

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C CHEST

(continued from page 20)

been improved to correct the 127-byte limit for flags passed to each of the compiler passes from the driver. There is still a 127-byte limit on invoking the compiler from the command line. We have also improved on the error recovery in the parser.

3. The internal error and problems with the *spawn* function have been fixed.

4. Because of requests from users of Microsoft C, we have included the C start-up code with Version 4.0 of the C compiler. It is considerably more than 100 lines of code, and these routines should be used only by experienced C programmers who have a complete understanding of C and MS-DOS. This will considerably help people who want to create ROMable code.

5. The documentation on the extensions *near* and *far* has been improved in Version 4.0.

"We feel that some of the problems that Allen discussed were based on incorrect assumptions:

• The differences between 'the way a Microsoft library routine works and . . . the equivalent Unix routine' are specified in Appendix B of the *Library Reference Manual*: 'A Common Library for XENIX and MS-DOS.' *[I missed it, sorry.—Allen]*

• In reference to '. . . *strncpy* pads out the string with nulls to the maximum count—why?', our implementation of *strncpy* is compatible with the Unix System V definition of *strncpy* as well as the definition in the developing ANSI standard. Both require padding of the target string. *[I still wonder why, but the problem isn't Microsoft's.—Allen]*

• With respect to Allen's concern about *#endif*: '. . . it ignores the last line of a file if it isn't terminated with a new line. An *#endif* without a *CR* gives an "unexpected end of file" message.' The developing ANSI standard (which we're following closely) specifies that a new-line character (*CR-LF*) is required as the last character of every source file that is referenced via an *#include* statement. Because any file may be referenced in this way, Microsoft C does not differentiate between included source and main source. *[Oh come off it. How hard can it be to check for* EOF *as well as* CR-LF*?—Allen]*

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I'm tempted not to carry this discussion any farther, but some of Ms.

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C CHEST
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Jacobson's points deserve comment. Though my remarks both here and in the original review are critical of the compiler (criticism is, after all, the point of a critical review), I do think the Microsoft C compiler is a good product (at least when contrasted with other available compilers). I use it myself. It could be a better product, though, and I'm hoping that a public discussion of its faults will spur Microsoft into making a few essential changes. All too often, new products are greeted with encomiums rather than real analyses, and I think that honest critique from a working programmer's perspective is important. Nobody benefits if I don't talk about problems I find in a product just because the manufacturer of that product claims that they'll be fixed in the next version. Even if the technical-support group can tell me about a bug over the phone, the bug still exists, and not everyone can spend lots of time on the phone to Washington. I don't want to antagonize Microsoft. What I do want is a better compiler, and I honestly believe that public discussion is the only way to bring this about.

I would love to say that the Microsoft C compiler is the greatest thing since peanut butter, but I couldn't say that about Version 3.0 without my nose growing several inches. I've not received a review copy of Version 4.0 yet, but it sounds as though most of the major faults in the compiler (at least the bugs and the error-recovery problems) have been fixed. I look forward to getting a copy.

One major problem that isn't addressed in the letter is the poor overall quality of the *User's Guide.* To my mind a user's guide for a C compiler shouldn't also try to teach you how to use DOS—that's what the DOS manual is for. I hope that Microsoft will seriously consider rewriting it for experienced programmers who can read above a sixth-grade level. As for technical support, at $400 for the compiler, I think Microsoft should, at the very least, send out an occasional newsletter listing all known bugs and work-arounds for them (I've suggested this to Microsoft, and it is considering it). If the firm doesn't tell you about a known bug, then the bug is undocumented, whether or not that bug was discovered after the documentation was printed. By the same token, the technical-support phone number should be a toll-free number (it isn't). Having to pay peak-hour phone rates to find out about a bug that should have been reported in a newsletter is just adding insult to injury. Finally, I don't consider sending in a bug report and getting an answer at some indeterminate future date to be adequate support. I want to call and get an answer right then. If the normal technical-support person can't answer a question, I want to be connected to someone who can. It seems reasonable to have to pay extra for this kind of support, but I think it should be available. (Microsoft is considering doing this, too.)

Microsoft, of course, is not alone in providing inadequate (I think) technical support, and in all fairness, it seems to be interested in improving its support process. I think there's a technical-support problem in the industry as a whole. A "these guys are just hobbyists, so what do they need source code or schematics for?" attitude seems to prevail. My fond hope is that Microsoft, which in my experience is a major offender in this department, will have a change of heart and lead the way for better technical support in the industry overall. All hardware should be shipped with schematics and a complete technical description. Period. All software documentation should explain low-level internals in depth, and source code should always be available if you need it. Period.

Lattice C, Version 3.0

I received a copy of Version 3 of the Lattice C compiler (3.0F to be exact) a few months ago, and I've finally had a chance to look at it. This version represents a significant improvement over previous versions. Function prototyping (strong type checking of subroutine arguments) has been added, and the compiler has been made more Unix-compatible overall (for example, *unsigned* is now a modifier rather than a type). The library has also been expanded considerably. If you have an earlier version of the compiler, I'd definitely recommend an upgrade, even if you have to pay for it.

To test the compiler, I recompiled all the routines in the /util program package that *DDJ*'s currently distributing. I found both good and bad things. The code-size problem has been addressed. The .exe files are now considerably smaller than they used to be. On the average, Lattice executables are only 7 percent larger than the Microsoft executables (generated from the same source code). Some of the Lattice executables are literally half the size of the Microsoft versions, however.

The compiler's error messages are pretty good, and there is now some *lint*-like support. For example:

```
foo( )
{
    int     i;
    return;
}
```

gives the error message "FOO.c 5 Warning 93: no reference to identifier 'i'." Like *lint*, however, this kind of error checking can generate needless noise. For example:

```
foo( )
{
    int i;
    int a=1;

    for( a; a; i++ )
        i = 6;
}
```

generated "FOO.c 6 Warning 94: uninitialized auto variable 'i'." I'd like to see a way to disable these *lint*-like error messages (with the exception of the function prototype warnings).

The Lattice compiler has several subroutines [*dosint( )*, for example] that have the same names, but different calling conventions, from those of the Microsoft compiler. This situation came about because they were originally the same compiler, but I wish one or the other of the manufacturers would change its subroutine names. Microsoft provides an include file with *#defines* that takes care of most of the changes. Lattice should provide a similar file to go in the other direction.

There are a few Unix I/O library functions missing from the library, though there are often functional

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C CHEST
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equivalents in the library. Lattice doesn't have a *stat( )* system call, for example. It has several functions that give you the same information as would *stat* [for example, *getfa( )* and *access( )*]. Nonetheless, I'd like to see a Unix-compatible function, too.

I also found a couple of trivial but annoying bugs—for example, the environment string vector array [pointed to by the *envp* argument to *main( )*] isn't terminated in the right place (there's one too many entries, and the last one is garbage).

A rather weird bug showed up when I tried to redirect-append (>>) the output from Lattice-compiled programs from the Microsoft-compiled shell. The Lattice-compiled programs overwrote the file rather than adding text to the end of it. The same programs had no problem when running under command.com, and they also worked fine with simple redirection (>) with the shell. I'm not blaming Lattice for this one [seeing as Microsoft C has *spawn( )* problems, I suspect the problem lies there], but the problem did arise.

Finally, Lattice told me that my version of the compiler had bugs in the in-line 8087 code generation. Though these particular problems should be fixed by the time you see this column, I haven't received an update so I can't verify this.

Perhaps the biggest potential problem with the compiler is the documentation. Lattice has returned to the insanity of a manual augmented with a *Technical Bulletin*. The manual I received was the same one that was shipped with Version 2.15. It is supplemented with a *Technical Bulletin* that is almost the same size as the manual. At least there's an index that references both volumes, but it's still annoying to have to go back and forth—I always seem to pick up the wrong volume. The *Technical Bulletin* lists all the library routines in strict alphabetical order, which is good. The manual itself does not, however—routines are grouped by function, another annoyance when you're trying to find something. Moreover, the bulletin doesn't have a functional index (one that groups library routines by function and then provides a capsule description of each routine). It has an alphabetical index with capsule descriptions, but this isn't much use if you know what you want to do but don't know the name of the routine that does it. A note came with the compiler saying that the company is working on a single, integrated manual that will be sent to all registered users at no charge, but I haven't seen this new manual yet.

Another problem is the amount of work you have to do to compile a program. The Lattice compiler comes with a horde of batch files and libraries. Even with these batch files, compiling is not a one-step process because you have to juggle parameters to the linker too. It's up to you to remember what libraries to link. One of the things I really like about the Microsoft compiler is the one-step cl driver program. It's an almost exact look-alike of the Unix cc driver and takes most of the pain out of compiling. It figures out what libraries to link and even invokes the linker for you. The Lattice compiler could benefit immeasurably from the inclusion of a similar driver program.

One final problem: The Lattice compiler still can't generate assembly-language source files directly. Lattice provides you with a program that disassembles object modules, but I've never liked this approach. It's just too awkward to use. With any new release of a compiler, it's critical to be able to see the code that the compiler generates. That's the only way to tell if an error is yours or if it is a bug in the compiler itself. Object-module disassembly makes it unnecessarily difficult to get at the assembly-language source. It's also another program that could potentially introduce bugs into acceptable object code (though I've never seen this happen, I worry about it).

In conclusion, I think this version of the compiler is significantly better than previous versions. Lattice is back in the running, at least in terms of features and code size. The compiler, in spite of all its improvements, is not a clear winner, though. Some of the problems (such as the 8087 bugs) are the result of a too-early release date. Similarly, the library documentation in its present form is not really acceptable (though it's a lot better than some manufacturers' documentation). The compiler is also harder to use than I'd like, and the library is not as Unix-compatible as I'd like. On the other hand, Lattice not only gives you root-module sources but will also sell you the source for the rest of the I/O library. (I've heard talk of Microsoft doing the latter, but I haven't seen an official announcement yet. Microsoft is releasing the root module with Version 4.0. Manx gives you all the sources if you buy its professional package.) Various sources for the error-processing routines are also included with the Lattice compiler package. So this, too, is a good product. I like it, but there's plenty of room for improvement.

Coming Attractions

Next month I'll continue looking at trees. I'll refine the in-order graphic traversal routine a little further, and I'll look in depth at AVL balanced trees. AVL trees are guaranteed to be almost perfectly balanced (the imbalance is at most one level), so they're very useful when you want a best-case access time and don't care if it takes a little longer to create the tree. I'll also look at the problem of deleting a node from a binary tree.

Availability

The shell is available from *DDJ* (see advertisement on page 78). All the code published this month is available both on CompuServe (type go ddjforum) and, for $25, on an IBM PC-compatible disk from Software Engineering Consultants, P.O. Box 5679, Berkeley, CA 94705. The tree routines that I'll look at next month are on the same disk.

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(Listings begin on page 68.)

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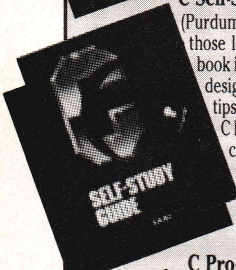

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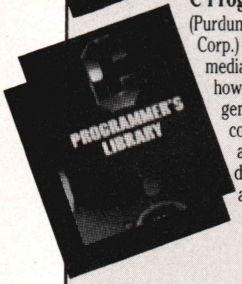

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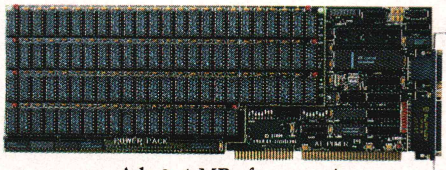
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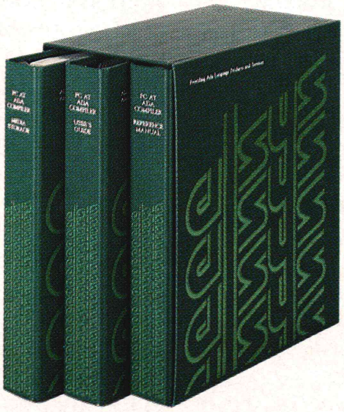

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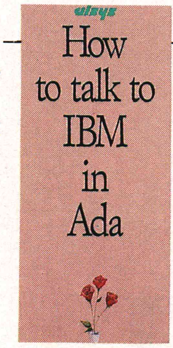

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A Forth Standards Proposal:

Extended Control Structures

by George W. Shaw II

The structures proposed in this article cover almost every control structure ever proposed.

The control structures in the Forth 83 Standard leave something to be desired. This is less stressful than it seems as all Forth programmers or systems implementors simply write their own prescriptions for the ills that plague them most. Unfortunately, of those published, all fail to supply a general solution to the problems, few are written in a manner that would pass the Standards Team, and none of them are part of the current standard.

Many partial solutions have been made public, but a complete solution becomes riddled with new words or plagued by unclear or nonstandard syntax. Many efforts solve only limited problems or do not maintain compatibility with existing control structures. It seems clear that often the authors are not aware of the general problem, are able to solve only a specific fragment, or overgeneralize their solution at the expense of compatibility and clarity.[1]

The Standard

Table 1, page 31, lists the syntax of the standard control structures. They are fairly simple. The standard does not specify the implementation of standard words, only their behavior. The code for the control structures in most Forth implementations, however, is very close to that presented in Listing One, page 82. (For clarity, compiler security is omitted.) Note that the listing includes the System Extension Word Set compiler-layer words *>MARK*, *>RESOLVE*, *<MARK*, and *<RESOLVE*. The System Extension Word Set nucleus-layer words *BRANCH* and *?BRANCH* are assumed available, as well as the nonstandard run-time words *(DO)*, *(LEAVE)*, *(LOOP)*, and *(+LOOP)*.

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There's more than one way to strip a parity bit, and the standard control structure words are no exception. One implementation variant of interest is *LEAVE*, which is used to exit a *DO* loop. The implementation options were the first step in reaching the solution presented in this article.

The History

In Forth 79, *LEAVE* does not exit *DO* loops directly but typically adjusts the *DO* loop's parameters so that the next time *LOOP* or *+LOOP* executes the loop will terminate. With the new, better *DO*-loop operation specified in Forth 83, the old *LEAVE* behavior no longer works. *LEAVE* cannot adjust the *DO*-loop parameters so that *LOOP* or *+LOOP* can reliably determine if they should terminate. A different behavior of *LEAVE* is required. Hence, Forth 83 specifies that *LEAVE* exits the loop immediately.

That is fairly straightforward, right? Wrong. Because *LEAVE* must be conditionally executed to be useful (see Table 1), it must have the ability to exit from within any structure in which it might be nested, to the point just past the next *LOOP* or *+LOOP*. Because Forth is very structured, during compilation almost all branch and structure addresses are simply nested on the stack and resolved from the stack. Thus, compiling an "unstructured" branch to just after *LOOP* or *+LOOP* pierces the nested levels and must be handled differently. To further complicate things,

the standard specifies that multiple *LEAVE*s are allowed in a *DO* loop. One of two approaches is usually taken to solve the compilation problem.

In the first approach, the address just after *LOOP* or *+LOOP* is stored with the loop parameters and is accessed when *LEAVE* is executed. It is easy to compile because there is no branch address to resolve during compilation. This approach also uses minimal overall memory and actually saves memory with multiple *LEAVE*s compared to the second approach. Its limitations are that all *LEAVE*s branch to the same place (not a problem within the standard) and additional loop parameter space is required for each nesting level of a *DO* loop.

The second approach is to allow each compiled *LEAVE* its own branch address. (See Listing One.) It uses minimal overall memory when a single *LEAVE* exists in a *DO* loop (99 percent of the cases) and just slightly more memory (for each branch address) than the first approach when multiple *LEAVE*s exist in a *DO* loop. This approach also uses minimal loop parameter memory and allows each *LEAVE* its own unique destination, albeit nonstandard. It appears difficult to compile, but this is not the case. The branch addresses are simply maintained in a linked list, the *LEAVE-LIST*, which is resolved by *LOOP* or *+LOOP*. Linked lists are often needed elsewhere in the Forth system, so the overhead of the compiling words *>MARKLIST* and *>RESOLVESLIST* may be nonexistent. Once you accept the power vs. compilation-complexity trade-off, some very useful structures can be built.

LEAVE naturally appears somewhat unstructured, though it does comply with the structured programming rule it seems to break most flagrantly. Structured programming requires that each program module have a single entry point and a single exit point. In a *DO* loop, the entry point is at *DO*, and the exit point is just after *LOOP* or *+LOOP*. *LEAVE* branches to just after *LOOP* or *+LOOP*. In a puff of logic, *LEAVE* becomes somewhat structured.

Common Extensions

Most Forth implementations extend the standard control structures a bit, frequently in the area of *BEGIN* loops. These are fairly simple and obvious extensions that, despite these facts, are nonstandard. If you replace the corresponding standard style code in Listing One with the code in Listing Two, page 82, you have typical extensions. These upgrades are significant, but no great shakes.

The behaviors of the typical extensions are not part of the standard but are compatible with it. They allow the syntax additions shown in Table 2, right. Code for the *CASE* statement listed in Table 2 is not supplied because it is probably not a candidate for standardization because its usefulness is limited. *OF* only allows checking for the equality case on a 16-bit value. If the values are equal, the code following *OF* is executed; otherwise execution continues after *ENDOF*.

Unresolved Problems

The extensions are useful and implementation is fairly simple, so what is the problem? (See Table 3, right.) All the problems listed stem from the desire to determine the exit trail of a loop. A programmer trying to write standard code is currently required to float a flag or value on the stack (heaven forbid you should use a variable) to indicate the exit trail. Because you cannot exit where you need to, you must retest after the loop for what you already knew when you were in the loop but had to lose.

The first three problems apply to standard control structures:

1. Because all *LEAVE*s branch to the same point, it is impossible, without retesting a flag or condition, to determine which exit was used.
2. Because *LEAVE* and *LOOP* or *+LOOP* continue after loop termination at the same place, it is impossible, without retesting a flag or condition, to determine how the loop was terminated.
3. There is no mechanism for directly exiting through multiple levels of *BEGIN* loops or *DO* loops. The only method currently available is to ripple a flag all the way out. Knowing how the loop was exited would also be useful here.

The last two problems apply only to common extensions:

4. Because all *WHILE*s in a *BEGIN* loop branch to the same

```
IF      THEN
IF      ELSE      THEN

BEGIN     UNTIL
BEGIN     WHILE     REPEAT

DO     LOOP
DO     +LOOP

DO     IF     LEAVE THEN     LOOP
DO     IF     LEAVE THEN     +LOOP
```

Table 1: *Forth 83 Standard control structures*

```
BEGIN     REPEAT
BEGIN     WHILE     WHILE ...  REPEAT
BEGIN     WHILE     WHILE ...  UNTIL

CASE     OF     ENDOF     OF     ENDOF ...  ENDCASE
```

Table 2: *Common nonstandard extensions*

Standard:
1. Can't handle each LEAVE exit separately without retesting for the exit condition after exit
2. Can't handle LOOP termination separately from LEAVE exits
3. Can't exit directly through multiple levels of begin-loops or do-loops

Common Extensions:
4. Can't handle each WHILE exit separately without retesting for the exit condition after exit
5. Can't handle UNTIL termination separately from WHILE exits

Table 3: *Limitations of standard control structures and common extensions*

Proposed Extensions

```
BEGIN   IF   LEAVES ... REPEAT   THEN
BEGIN   IF   LEAVES ... UNTIL   ELSE   THEN

BEGIN   IF   LEAVE THEN ... REPEAT
BEGIN   IF   LEAVE THEN ... UNTIL

BEGIN   BEGIN   IF   LEAVES ... REPEAT OUTSIDE   REPEAT   THEN
BEGIN   BEGIN   IF   LEAVES ... REPEAT OUTSIDE   UNTIL   ELSE   THEN

CASE   IF   LEAVES   IF   LEAVES ... ENDCASE

DO   IF   LEAVES ... LOOP   THEN
DO   IF   LEAVES ... +LOOP   THEN

DO   DO   IF   LEAVES ... LOOP OUTSIDE   (+)LOOP   THEN
DO   DO   IF   LEAVES ... +LOOP OUTSIDE   (+)LOOP   THEN
```

Suggested Additions for Efficiency

```
DO   ?LEAVE   LOOP
DO   ?LEAVE   +LOOP

DO   ?LEAVES   LOOP   THEN
DO   ?LEAVES   +LOOP   THEN

IF   IF ... IF   THENS
IF   IF ... IF   ELSES   THEN
```

***Table 4:** Proposed extensions and additions*

```
IF   THEN
IF   ELSE   THEN

BEGIN   UNTIL
BEGIN   REPEAT
BEGIN   WHILE   REPEAT
BEGIN   WHILE   WHILE ... REPEAT
BEGIN   WHILE   WHILE ... UNTIL

BEGIN   IF   LEAVES ... REPEAT   THEN
BEGIN   IF   LEAVES ... UNTIL   ELSE   THEN

BEGIN   IF   LEAVE THEN ... REPEAT
BEGIN   IF   LEAVE THEN ... UNTIL

BEGIN   BEGIN   IF   LEAVES ... REPEAT OUTSIDE   REPEAT   THEN
BEGIN   BEGIN   IF   LEAVES ... REPEAT OUTSIDE   UNTIL   ELSE   THEN

DO   LOOP
DO   +LOOP

DO   IF   LEAVE THEN   LOOP
DO   IF   LEAVE THEN   +LOOP

DO   IF   LEAVES ... LOOP   THEN
DO   IF   LEAVES ... +LOOP   THEN

DO   DO   IF   LEAVES ... LOOP OUTSIDE   (+)LOOP   THEN
DO   DO   IF   LEAVES ... +LOOP OUTSIDE   (+)LOOP   THEN

DO   ?LEAVE   LOOP
DO   ?LEAVE   +LOOP

DO   ?LEAVES   LOOP   THEN
DO   ?LEAVES   +LOOP   THEN

CASE   IF   LEAVES   IF   LEAVES ... ENDCASE

IF   IF ... IF   THENS
IF   IF ... IF   ELSES   THEN
```

***Table 5:** Proposed standard control structures*

(continued from page 31)

point (just after *REPEAT* or *UNTIL*), it is impossible to determine which exit was used without retesting a flag or condition.
5. When an *UNTIL* terminates a *BEGIN* loop containing one or more *WHILE*s, it is impossible to determine how the loop was terminated without retesting a flag or condition.

About 90 percent of the loops coded can be coded without too much effort. It is difficult, if not impossible, to code the other 10 percent without resorting to setting a variable or using some other unworthy method. Without solutions similar to those below, many programmers have spent hours trying to code reasonably efficient complex loops.

Proposed Extensions

Having collected this information, what can be deduced about the problem?

1. The exit/termination cases following loop execution need to be handled better.
2. The problems are identical for both *DO* loops and *BEGIN* loops.
3. The loop exit word must be executed conditionally to be useful.
4. The *THEN* following *LEAVE* is redundant because no code between *LEAVE* and *THEN* can ever be executed.
5. Given that the conditional exit test produces only *exit* and *don't-exit* results, there are only two cases that must be made programmable: the *exit* case and the *don't exit* case.

Given these deductions, the following preferences are likely:

1. Because the problems are the same for both *DO* loops and *BEGIN* loops, a common syntax would be valuable—something such as *LEAVE* but more flexible.
2. Because the exit word must be used conditionally, introduction of the word with an *IF*-type word is necessary. A syntax similar to *LEAVE* is probable.
3. Because the *THEN* after *LEAVE* is redundant, our word should incorporate the *THEN* function.
4. Because the destination of our exit branch is determined by the programmer, a *THEN*-type destination marker is necessary.
5. Because the *don't-exit* condition continues execution after the *IF-ELSE-THEN* clause (at the old *THEN* point) and execution after *exit* resolves to execute elsewhere, our exit word could be considered analogous to *ELSE*.

We might now draw the following conclusion: A conditional exit with a structure similar to *IF-ELSE-THEN* would be appropriate, with the *IF-ELSE* part existing inside the loop and the *THEN* part indicating the destination. Furthermore, the current *IF-ELSE-THEN* words perform exactly the desired functions, except that the *ELSE*-type word needs to discard the loop parameters when exiting a *DO* loop. Hence, if a word were added to the *IF-ELSE-THEN* family to perform the appropriate *ELSE*-type func-

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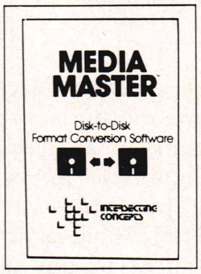

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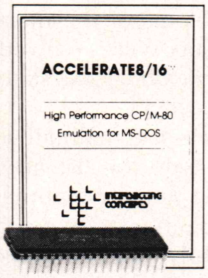

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(continued from page 33)

tion, a complete structure and syntax would exist.

The proposed word is *LEAVES* and belongs to the *IF-ELSE-THEN* family. The name is appropriate, being similar to *LEAVE*. It reads well, and it expresses immediacy. The word *OUTSIDE* is also proposed to allow exiting several levels of *BEGIN* loops or *DO* loops directly. Examples of their uses are represented in Table 4, page 32. The additional words presented in this article are proposed to be part of the standard as a new word set, or even better as a new level above the existing Required Word Set.

Implementation

As described above, the Forth 83 *LEAVE* was not obvious to implement. It does, however, open the door to the control structure implementation solution. Thanks to David Harralson, whom I met at the 1985 FORML Conference in Asilomar, California, for extending the concept. He presented a paper there [2] that seemed to solve all the problems (and more) but completely lacked compatibility with the current standard. We formed a working group at the meeting to discuss the problem, spent several hours on the telephone, and exchanged several letters during the months that followed. His functional but nonstandard implementation, combined with a partial solution I had already achieved,[3] evolved into the results seen here. By working together we were able to extract the key concept from his paper: All forward references are to be maintained in linked lists during compilation.

We actually took his paper and worked backward, eliminating the overgenerality of his structures that prevented them from being standard compatible. I then resolved the syntax difficulties and decided upon behavioral rules for *LEAVES* and *OUTSIDE*. Finally, I spent many hours staring at the walls and scrawling on paper until one by one the implementation problems of the more conservative standard-compatible syntax were resolved. Out of this also came an almost free, flexible *CASE* statement. Listing Three, page 82, is the result.

As mentioned, all forward references are maintained in linked lists. Harralson prefers to keep the list head pointers on the stack; I prefer to use variables (sometimes a useful poison). I find the variable implementation much more clear even though it may be slightly larger. It is also more easily modifiable if additional forward referencing structures are added in the future.[4]

Three words need to be added to the System Extension Word Set to handle forward compiled linked lists: *>MARKLIST*, *>RESOLVELIST*, and *>RESOLVESLIST*. (See Listing Three.) Notice that the first and last words are already in the system if approach 2 (Listing One) is taken to implement the standard *LEAVE* operation. If the extended control structures presented here are adopted, I would expect that all three words have a very good chance of becoming standard.

Three lists are maintained by the system:

1. The *IF-LIST* links all *IF* and *ELSE* branches. These branches are resolved by *ELSE* and *THEN* respectively. The *IF-LIST* is also used to hold the unresolved *LEAVES* branches once outside the loop structure. This is how *LEAVES* can be resolved by *ELSE* or *THEN*.
2. The *LEAVES-LIST* contains all *LEAVES* branch addresses while inside a loop. The list is transferred to the *IF-LIST* after the loop end is compiled to allow the *LEAVES* to be resolved by appropriate *ELSE*s or *THEN*s.
3. The *LEAVE-LIST* is a list of *LEAVE* branch addresses, maintained for compatibility with the current *LEAVE* function. The list is resolved by *LOOP*, *+LOOP*, *REPEAT*, and *UNTIL*. *LEAVE* can be used inside either *DO* loops or *BEGIN* loops.

Another variable maintained by the system is *LEAVE-CF*. This variable is the key that allows *LEAVE* and *LEAVES* to work in both *BEGIN* loops and *DO* loops. *CASE*, which is used by *BEGIN*, and *DO* set the value of *LEAVE-CF* to *BRANCH* and *LEAVE* respectively. *LEAVE-CF* thus contains the compilation address (code field) of the proper run-time routine to be compiled by *LEAVE* or *LEAVES*, depending upon whether a *BEGIN* loop or a *DO* loop is being compiled. The compilation addresses of other exit routines can, of course, be stored in *LEAVE-CF*. This allows *LEAVE* or *LEAVES* to be used to exit almost any structure added to Forth. To allow proper structure nesting, all list heads (*IF-LIST*, *LEAVES-LIST*, and *LEAVE-LIST*) and the value of *LEAVE-CF* must be saved during compilation and the lists set to 0 at the beginning of each new structure (*BEGIN*, *DO*, and *CASE*). The heads' values and *LEAVE-CF* are restored at the end of each structure (*UNTIL*, *REPEAT*, *LOOP*, *+LOOP*, and *ENDCASE*).

Comparing the complexity of the new implementation of the *IF-ELSE-THEN* structure in Listing Three to that in Listing One, you can see that there is little significant difference. Also, comparing the complexity of the new *BEGIN-WHILE-REPEAT* to that in Listing One (ignoring *LOOPEND* for a moment) or better yet to the commonly extended version in Listing Two, you can see that here too there is little significant difference. The proposed structures' complexity is even less in one area, as *WHILE* is now an alias for *IF*. The *DO* loop words also follow this tradition with no significant difference in complexity (*LOOPEND* somewhat aside).

Capability is not free, and complexity rears its ugly head in *LOOPEND*. First, within *LOOPEND*, the backward branch is resolved to the beginning of the loop, and then an entire linked list of branches is resolved to the point immediately following the end of the loop. For *DO* loops this is the *LEAVE-LIST*, and for *BEGIN* loops it is the *IF-LIST* (to resolve the *WHILE* exits). *BEGIN* loops also resolve the *LEAVE-LIST* after *LOOPEND*. If any *LEAVES* were compiled, the list heads are restored and then the end of the *LEAVES-LIST* is found and is linked to the front of the *IF-LIST*. The new longer list replaces the *IF-LIST*. This slightly complex but necessary process allows *THEN* to be used to resolve *LEAVES*. The process might be simplified if two additional words were added to replace *ELSE* and *THEN* in resolving operations on the *LEAVES-LIST*. This unfortunately interferes with the operation of *OUTSIDE*. Harralson and I feel that these are simply two more words added to remove a small amount of complexity that can be hidden within the bowels of the system word *LOOPEND*, especially when the *IF-LEAVE-THEN* syntax must be retained for compatibility with the current standard.

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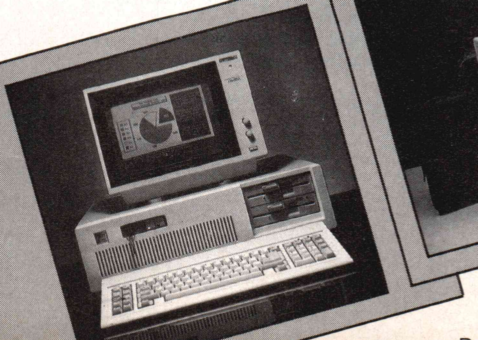

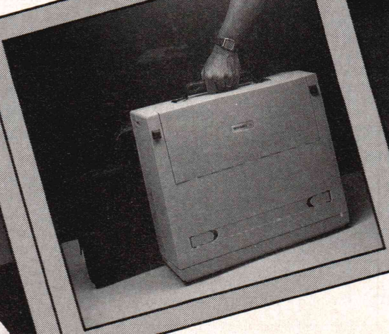

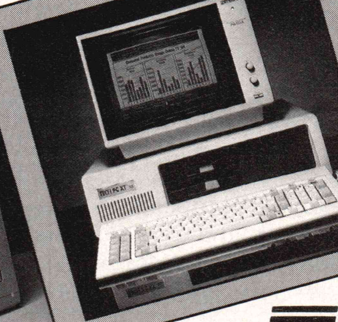

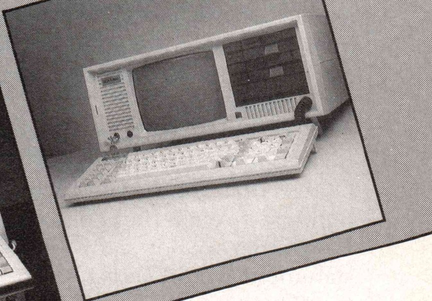

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(continued from page 34)

The last looping-related word is *OUTSIDE*. This word must keep the branch address of the most recent *LEAVES* available to be resolved outside the next level of loop. This is accomplished by simply unlinking the top item from the *IF-LIST* into the the top of the *LEAVES-LIST*. Outside the next level of loop, the branch address will be transferred back to the *IF-LIST* again by *LOOPEND*. This process can be repeated as necessary. When multiple *LEAVES* are used, *OUTSIDE* can be placed between *LEAVES* resolutions to work upon the correct one. *OUTSIDE* must also ensure that *LEAVES* unnests the correct number of *DO*-loop levels. Unfortunately, I cannot disclose this mechanism because it is proprietary to my company's product. Note that because of this difference in unnesting requirements, the listed code for *OUTSIDE* will not properly unnest through a nested mixture of loops. Though easy to solve, this too is proprietary.

The proposed structures give you an almost free implementation of a *CASE* statement. It compiles in a manner exactly equivalent to nested *IF-ELSE* statements but with a more readable syntax and a single syntactic nesting level. This is equivalent to the *else if* clauses available in C, Pascal, Ratfor, and Ada.[5] It can also be implemented more directly by implementing *THENS*. (See Listing Four, page 83.) Similarly, the *ANDIF* proposal can be easily implemented by defining *ELSES*.[6] (See the examples in Listing Five, page 83.)

The new *LEAVES* structure seems even more unstructured than the old *LEAVE*. This is not so. The single exit point of the module simply needs to be redefined. The program flow rejoins at the *THEN* of the outsidemost *LEAVES*—hence one entry point, one exit point. In another puff of logic, even *LEAVES* is somewhat structured. Working with the same rules, when *OUTSIDE* is considered, the module becomes the outsidemost *DO* to the outsidemost *THEN*, which resolves a *LEAVES* within. It is a much harder logical stretch, but even when *OUTSIDE* is considered, this oft-broken rule of structured programming is somewhat fulfilled.

Conclusions

Listing Five lists examples of almost every control structure proposal published or presented to date and the corresponding solution using the structures proposed in this article. All the bases seem to be covered. Some proposals may have been omitted, but hopefully none represent structures that are not adequately covered by the included proposals.

Using linked lists for all forward references might be questioned. Creating a new *IF*-type structure for the *LEAVES* operation would have solved that class of problem just as well, though it would have added additional words that are not really necessary. The almost-free *CASE* statement would vanish in an imposed limitation of syntax. This would complicate *OUTSIDE* and preclude the useful *ELSES* and *THENS* operations without adding words to mark their limits. (See the *<STEPS* example in Listing Five.)

Table 5, page 32, summarizes the syntax of the control structure word set proposed for standardization. It is completely compatible with the current standard control structures and the most common nonstandard extensions. It appears to emulate all the tricks that have been proposed to date for these classes of control structures. It implements in 19 words (28 including the System Extension Word Set) all the described functions compared to 33 words (41 including the System Extension Word Set) to summarize the other proposals. The current standard has 11 words (17 including the System Extension Word Set). The material in this article was presented to the March 1986 meeting of the San Francisco Chapter of the Forth Interest Group, and the members voted two to one in favor of standardization. I hope the enthusiasm continues.

Notes

1. David W. Harralson, "Extending FORTH Control Structures into the Language Requirements of the 1990's," *Seventh FORML Conference* (1985).
2. Ibid.
3. George W. Shaw, "Extended Control Structures for Forth," *Seventh FORML Conference* (1985).
4. Harralson, "Extending FORTH."
5. Wil Badin, "Modern Control Logic," *Fifth FORML Conference Proceedings* (1983).
6. Wendell C. Gates, "ANDIF and ANDWHILE," *Forth Dimensions*, vol. VI, no. 4.

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DDJ

(Listings begin on page 82.)

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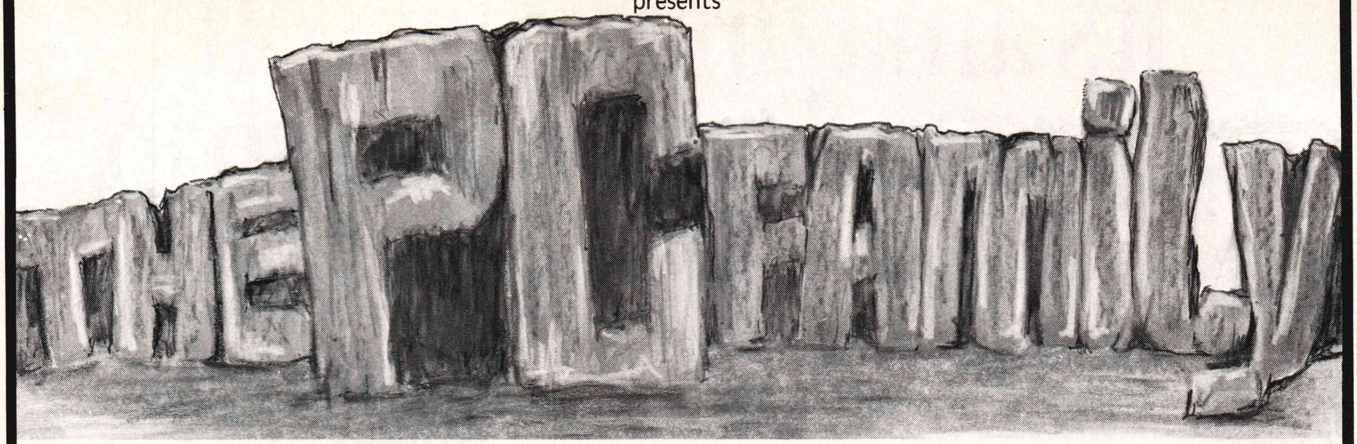

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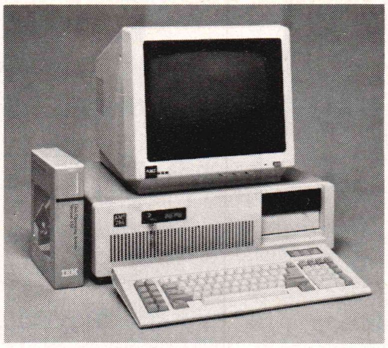

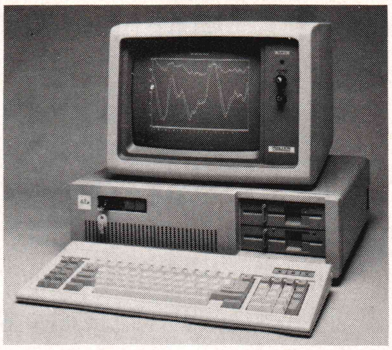

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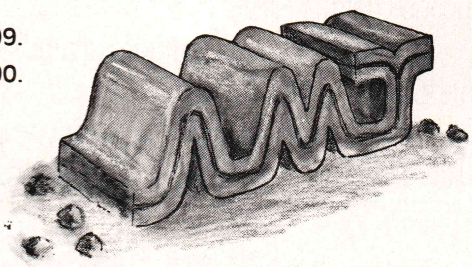

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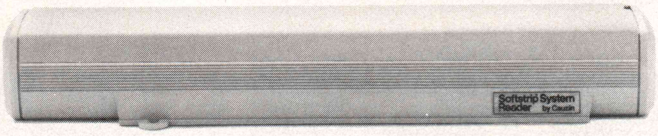

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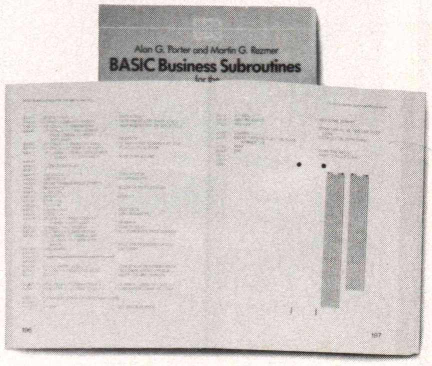

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The game of **LIFE** was invented years ago by John Horton Conway. Over the years, the game has evolved into a popular cerebral exercise for programmers and math majors alike. At first the game was played on graph paper, but the advent of modern technology moved it to the computer which plays the game thousands of times faster. Now millions of computer enthusiasts are captivated by this devilishly simple, yet marvelously complex quintessential computer diversion.

The rules of the game are quite simple. Imagine that you have an infinite grid of squares, each one being either alive (on) or dead (off). Each square (called a "cell") lives or dies into the next cycle (called a "generation") based on its current state and that of its neighbors. The grid of cells is represented by a graphic display on your computer screen. After setting up an initial configuration of living and dead cells, you start the simulation. The patterns will change on the screen as cells live and die.

Mr. Park's improvement on the theme is interesting because of his approach. Instead of writing a traditional program for the simulation, he has created an array of intelligent cells using an inference engine written in Expert-2, a superset of FORTH.

Read in the data strips, following the directions that came with your Cauzin reader. You'll need the Expert-2 programming environment to operate this program. Refer to Mr. Park's article in this issue for operating instructions.

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Forth Goes to Sea

by Everett Carter

Forth has a long history in process control and data acquisition, but its use in oceanography is new.

This article describes an implementation of the Forth language for the control of a microprocessor-driven laboratory instrument. The laboratory in this case is the ocean; the processor is the Motorola MC146805, a CMOS 6805 chip. I implemented a ROM-based Forth for this chip following the Forth 79 Standard as closely as possible, but the final version (Listings One and Two, pages 84 and 88) has several differences from the standard. The deviations from the 79 Standard are because there is no mass storage and all the code must reside in ROM. Memory constraints are also important because everything—the managing software and the data itself—must fit within 8K.

The RAFOS Float System

Our research group in the Graduate School of Oceanography at the University of Rhode Island has spent the last two years studying the Gulf Stream current in the Atlantic Ocean. The primary instrument we have been using is known as a RAFOS float.

The origin of the name is somewhat convoluted. In the ocean there is a sound conducting channel, like a waveguide, called the SOFAR channel. Its depth varies, but in the Atlantic it's about 800 meters deep. Early in the 1970s, this channel was utilized in a neutrally bouyant float. These early floats drifted in the channel emitting sound pulses at precisely known times. Listening stations on shore picked up the signals, and by triangulating from several stations, the float positions were determined. These floats were called SOFAR floats. We're now using new floats that listen passively to fixed sound sources. They thus work in the opposite fashion from SOFAR floats, hence their name RAFOS, which is SOFAR spelled backward.

Everett Carter, Graduate School of Oceanography, University of Rhode Island, Kingston, RI 02881

The RAFOS float is made of Pyrex glass, is about five feet long and about four inches in diameter, and looks like a big test tube. Inside it are various sensors, batteries for power, a radio, and an MC146805 microprocessor that controls them all.

Our sampling scheme involves tossing the float into the water (whereupon it sinks to the proper depth) and letting it drift freely for 30 to 45 days in the Gulf Stream. After the allotted time, the float drops its ballast weight and comes to the surface. It then turns on the radio and transmits its data to shore via satellite. We make no attempt to recover the float—it would cost more in ship time than it cost us to build the float.

Beginning last fall, we have been contemplating how to utilize the next generation of floats. These floats will be used as before but with adaptive sampling strategies or for shorter intervals interactively with a ship. An interactive scenario could involve, for example, putting a few floats in for a few days and recovering them from the same ship, which then puts in more floats in a way that depends upon the data received from the first floats.

The original RAFOS floats were all programmed in assembly language, and all the floats had the same program. Assembly code for the interactive floats would be a nightmare (imagine writing machine code late at night, while seasick, so you can do the experiment the next day!). Forth was the obvious solution to the problem of how to get the sampling program into the float efficiently.

The MC146805 Processor

As mentioned previously, the processor in the float is the Motorola MC146805, which is basically a CMOS 6805. The 6805 is a 6800 that has been specialized for process controlling. It was the only CMOS alternative to the 1802 when the floats were first designed several years ago. It is not the ideal choice for the implementation of Forth. In specializing from the 6800 to the 6805, half the registers and several instructions were thrown away and the stack could not be accessed (it saves only return addresses for calls and interrupts and the registers during interrupts).

One class of instructions that are particularly useful in implementing Forth are the indirect ones. An indirect jump instruction causes the processor to jump to an address that was pointed to by the contents of a location, and that location is identified by a register or other memory location. Some processors have a whole family of indirect instructions, jumps, reads, writes, and so on. Some of these instructions I learned to live without; others I had to emulate in self-modifying software.

The 6805 comes in several versions. The one I am using has a memory address space of only 8K, which puts severe restrictions upon the system because everything—the operating system, the application program, the memory-mapped sensor ports, and the data—must all coexist in only 8K. In the early floats that were programmed in assembly language, the code occupied the top 4K (from 1000

hex to 1FFF), and the data was stored in the lowest 4K. This Forth implementation tries as much as possible to preserve the historical partition (it nearly succeeds).

The Format of the Header

In order to conserve the system's memory usage, the structure of the headers is modified slightly. Only the character count and the first three characters are saved in the header. This is as if the Forth variable *WIDTH* was set to 3 (note that *WIDTH* does not explicitly exist in this implementation and that all words that would use it treat it as a constant that is equal to 3). The count byte has the following structure. The natural character count is in the low 5 bits (hence allowing words up to 31 characters long). The sixth bit is the smudge bit; it equals 1 when the word is smudged, thus preventing a match by *−FIND* and similar words. The seventh bit has no defined use. The eighth bit is normally 0 but is set to 1 for immediate words (this bit is called the precedence bit). Although strictly this structure does not violate the standard, it is not the usual one. Traditionally, bit 8 is always set to 1 and bit 7 is the precedence bit. The traditional structure was not used in order to make *WORD* smaller—*WORD* masks out the high-order bit of every byte that it examines in a given word's name field when it is trying to find a match. In the traditional format, the count byte has a different mask from that of the rest of the name field.

The format of the header is thus the count byte, followed by the first three characters of the word, a pointer to the name field (that is, the count byte) of the previous Forth word, and finally the actual code for the word. Note that last point. After the link is the actual code—that is, the code field, not the code field address.

The Inner Interpreter

The Forth interpreter is implemented as a direct threaded interpreter because of the limited ability of the 6805 processor to perform address indirection. My reading of the standard is that it does not specify the type of interpreter you should use, but the interpreter is usually implemented as an indirect threaded interpreter. The direct threaded approach means that the code field is not pointed to by a pointer, but the code actually begins where a traditional *CFA* pointer would normally be (so that ' returns the address of the code field, not the address of the pointer to the code field). This means that you must exercise care in using Forth words that manipulate addresses (*CFA*, *PFA*, *NFA*, *'*, and so on) if you are accustomed to using more traditional Forth implementations.

Forth in ROM

Even though this implementation of Forth is designed to be ROM-based, some code resides in RAM for special reasons. The 6805 has special, fast instructions for access to the base page (0000 to 00FF hex). The instructions are fast because fewer bytes are used in those instructions and because some of the base page resides physically within the processor chip itself. Because the processor will spend the bulk of its time in the inner interpreter, the inner interpreter is designed to reside in the base page (starting at 0080 hex).

All the self-modifying code must reside in RAM in order to work; this code immediately follows the inner interpreter in RAM. The limited instruction set of the 6805 required the simulation of some instructions (such as indirect jumps) through the use of self-modifying code. In many places I found I needed two routines—one to load register *A* into a pointed-to address (an indirect write) and one to

TYPE	EXIT	EXECUTE	EMIT	BL
WORD	<NUMBER>	DROP	C@	@
DP	HERE	NOT	1+	HLD
STATE	CONTEXT	CURRENT	FORTH	!
C!	,	C,	DUP	+!
LATEST	ALLOT	LIT	COLD	QUIT
SWAP	SP!	CR	CREATE	TOGGLE
IMMEDIATE	−FIND	COUNT	0	1
2	2+	[	]	DEFINITIONS
+	−	U*	U/MOD	S−>D
PAD	<#	OVER	#>	>R
R>	R@	ROT	HOLD	M/MOD
BASE	SMUDGE	ABS	0<	0=
<	>	=	SIGN	NEGATE
+−	#	OR	AND	XOR
DDUP	#S	.	COMPILE	;
:	'	VARIABLE	CONSTANT	*
[COMPILE]	BEGIN	AGAIN	UNTIL	IF
THEN	ELSE	WHILE	REPEAT	<.">
TIB	>IN	'STREAM	<DO>	<LOOP>
<+LOOP>	DO	LOOP	+LOOP	DNEGATE
I				

Table 1: *List of initial Forth words*

DP	01D0	the dictionary pointer
START	1E57	where the outer interpreter is
BASE	10	initial base is hex (note that this is a single-byte variable)
FORTH	17E6	points to the NFA of the last dictionary entry (I)
CONTEXT	0039	points to FORTH
CURRENT	0039	points to FORTH

Table 2: *The initial values of the system variables. All values are hexadecimal.*

(continued from page 41)

get the value at that address into *A* (an indirect read). I called these routines *LOAD* and *GET* in the assembly listing. For generality, I wrote them to include a possible offset defined by register *X*. Many routines will define the 16-bit address defined at *LOAD+1* or *GET+1* and call *LOAD* or *GET*. Because they get modified, *LOAD* and *GET* are in RAM, and because they can be called frequently, they are in the base page.

The self-modifying code goes beyond the base page, but I made an effort to place the most frequently called portions within the base page. The predefined user variables (*FENCE, STATE, FORTH, CONTEXT, CURRENT, BASE, HLD, DP, IN,* and *OUT*) and the system variables (*IP, RP,* and *SP*) also reside in the base page.

When the system is booted, reset, or upon execution of *COLD*, the initial values of the user and system variables, the inner interpreter, and the self-modifying code are all copied from ROM to their executable locations in RAM. A note about how the code was developed: The assembly code was cross assembled on a VAX 750 using the XASM6805 cross assembler from Intelligent Devices of Minnesota (P.O. Box 492, Anoka, MN 55303). The IDM cross assembler does not allow the assembly of code at one location for execution at another. The code was thus written for its target address, then the hexadecimal assembly output file (which is in Motorola's S1 format, similar to the CP/M HEX format) was edited manually to change the compilation address for the dozen or so lines that needed changing.

The initial vocabulary consists of the words listed in Table 1, page 41; the system variables are initially set to the values shown in Table 2, page 41. The vocabulary is not a full Forth word set, but most of the important (non-mass-storage) words are there. We usually upload all the MOD arithmetic words from a microcomputer that we use as a terminal when we use the float; this is how the data-sampling words get loaded as well. The initial system memory map is shown in Figure 1, left. The variable *START* (at address 002E hex) does not have a header. It is a warm boot execution vector (that is, the address at that location is executed when *QUIT* is invoked), and normally it points to the start of the outer interpreter. A word that is pointed to by *START* should be a Forth word that is an infinite loop (such as a *BEGIN... AGAIN* structure) because it is effectively the outer interpreter once *QUIT* is executed. Note that *QUIT* is a warm boot; it does a partial system reset. It clears the stacks and sets the system state to execute, then it goes to the address pointed to by *START*. *COLD* runs the same code as the power-up or reset interrupt does—it resets the dictionary pointer and *FORTH* to their power-up default values and sets the *CONTEXT* and *CURRENT* vocabularies to *FORTH*. (All this is done by executing the ROM-to-RAM copy described above.) It then falls through to *QUIT*.

Error Checking

In order to minimize the size of the system, only a minimal amount of error checking is implemented. If the system does not find a word in the dictionary and it cannot subsequently interpret it as a number, that word is echoed back to the terminal, followed by a question mark. When this happens the user stack is unaffected, but the *FORTH* return stack is cleared. Clearing the return stack effectively denests the system from any process out to the outer interpreter. The system is then waiting for user input. If the system was in the compiling state when the error occurred, it will be in the execution state after the error message. This means that if a word was not found during compilation,

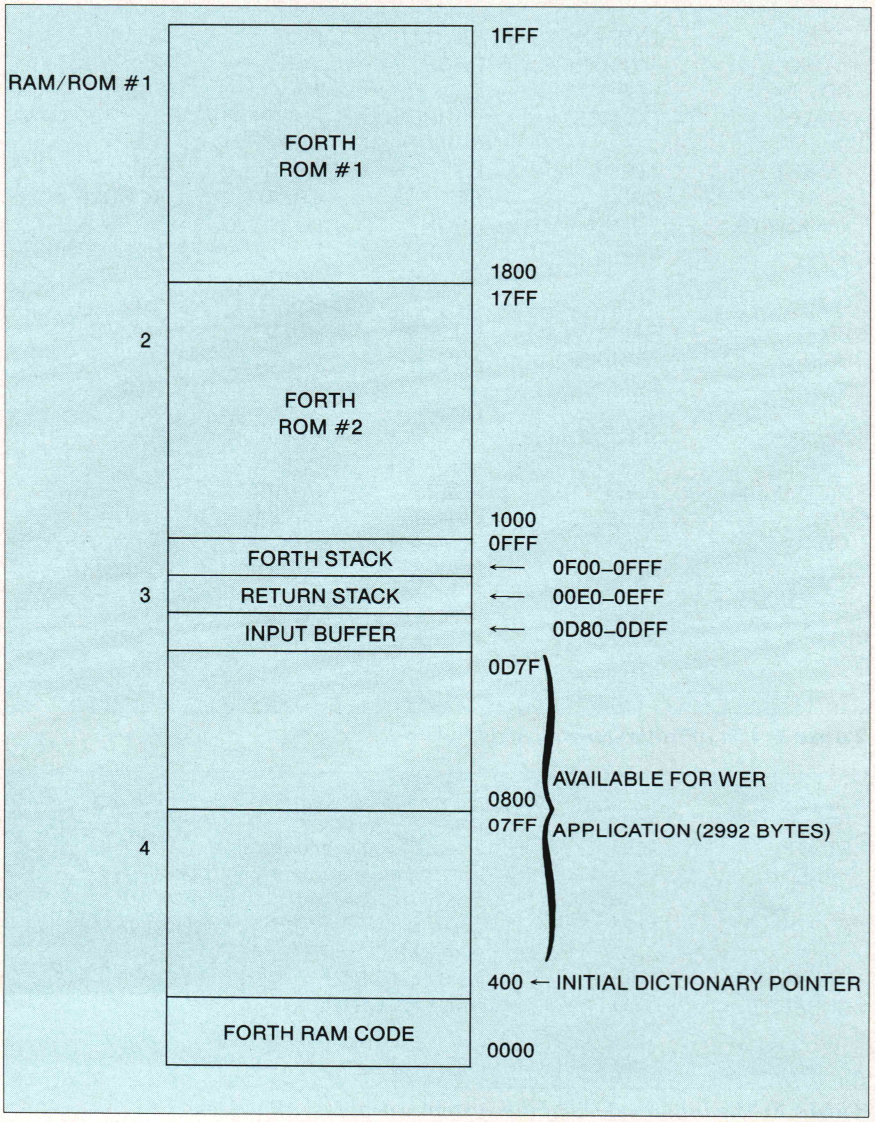

Figure 1: Memory map

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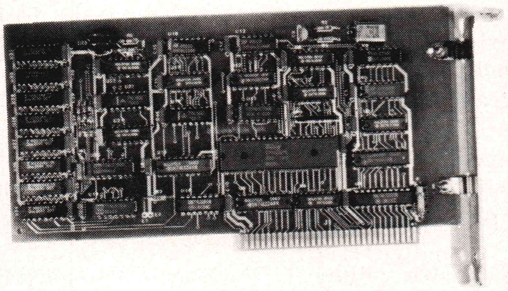

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(continued from page 42)

you have to start the definition from the beginning and not from the point where the error occurred. This behavior for compilation errors is common to many Forth implementations.

It should be noted that the word that was being compiled into the dictionary at the time is in the dictionary in a smudged state. Normally this is alright because the word cannot be found and accidentally executed. If *FORGET* has been compiled, though, the partially compiled word cannot be forgotten unless *SMUDGE* is executed before any more manipulation of the dictionary occurs.

Stack errors are not announced. This is not as bad as it first sounds because both the return stack and the user stack are implemented as 128-word circular queues. Being circular, a runaway stack cannot damage anything but the stack itself. With 128 words in the stack, it's not likely that anything useful in the stack would be corrupted by a stack error. It does mean, though, that if a program pops data off an empty stack, it will continue on, using whatever it happened to find as data, without ever telling you that there was no data there in the first place.

Other error messages are not implemented. Specifically, these include:

1. Incomplete definitions—Improperly paired *DO . . . LOOP*, *IF . . . THEN*, *BEGIN . . . UNTIL*, and similar structures are not detected. Words that are compiled with incomplete structures will probably compile with no trouble, but trying to execute such a word will almost certainly crash the system.
2. Inappropriate execution—Attempts to execute words that are compile only, such as *DO . . . LOOP*, are not flagged. Trying to execute such words will crash the system.
3. Defining a word that already exists—In a normal Forth system, redefining a previously existing word causes a nonfatal warning message to be issued and compiling may continue. In this system, no message of any sort is issued and the continued compiling is allowed.

Major Deviations from the Standard

In a few cases, I deviated from the defined 79 Standard for special reasons. In the spirit of Mountain View Press' Forth implementations, one thing that I did was replace words of the form (xxx) with <xxx>. This is because the close parenthesis in (xxx) words causes trouble with Forth comments.

<NUMBER>, the word that tries to interpret input as a number, does not recognize double-precision numbers. This is a violation from the standard and was done in order to reduce the size of the system. Also, *<NUMBER>* takes an address as input and returns either a false flag (0) if the conversion fails, or it returns a true flag (hex FFFF) and an address of the result if the conversion succeeds. The Forth word *NUMBER* would be defined as the following (except for the matter of double-precision mentioned above):

```
: NUMBER <NUMBER> NOT IF ABORT"
                    NOT RECOGNIZED" THEN ;
```

The word *NOT* is defined in a nonstandard way. It returns the one's complement of the value on the stack. Normally *NOT* is a synonym for *0=*, which returns a true (hex FFFF) if a 0 is on the stack and a false (0) otherwise. This version of *NOT* will allow proper execution of standard Forth words that use *NOT* to complement the result of a logical test (. . . 9 = NOT . . .). If, however, a standard Forth word uses *NOT* when *0=* is actually meant (for readability reasons perhaps), then the program will not behave properly. This change was made because it was thought to be more useful for process-control routines to have a one's complement word directly available.

The word *BASE* is a 1-byte variable instead of the usual 2-byte form. This means that *BASE* should be accessed and manipulated by using *C@* and *C!* instead of *@* and *!*. Similarly, *>IN* is a 1-byte variable. The word *TIB* is a constant, not the usual variable, so the location of the input buffer cannot be changed.

The Future

To date (March 1986) none of the Forth-controlled floats have actually gone to sea. So far they have been used on the lab bench to evaluate the new sensors that will be on board the floats that are to go into the water this coming fall.

The lab bench floats are not in their glass tubes, so communicating with the CPU is just a matter of plugging into the I/O port (port B in the listings). With the seagoing floats, the details of the communication link are still an open issue. The link will either involve a watertight connector that goes through the glass wall or orthogonally mounted (in order to avoid interference) optical links.

A second vital use that these floats are serving is to teach the rest of the research group the Forth language. Forth has a long history in process control and data aquisition, but its use in oceanography is relatively new. Having RAFOS float CPUs with Forth ROMs readily available has proved invaluable as a teaching aid for learning Forth.

As a final footnote, I should point out that the code in Listings One and Two is the result of one person's total immersion in the implementation process. As such it could very well suffer from the lack of multiple critical perspectives on its design. I would welcome critiques of the result.

Bibliography

I have listed below a few Forth references that were my constant companions while working on this implementation. In addition, there is a short paper describing the first results from the first generation of RAFOS floats.

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(Listings begin on page 84.)

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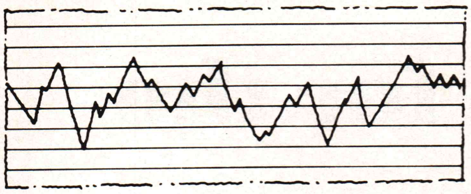

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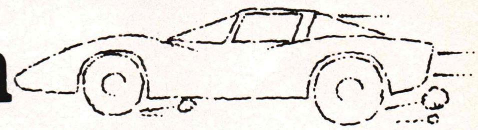

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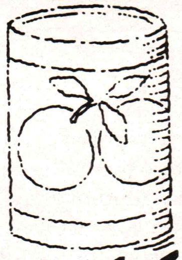

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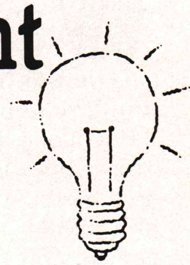

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Forth Windows for the IBM PC

by Craig A. Lindley

The demo program shows how to integrate the window package with an application.

Windows provide a method of presenting information to computer users in an easy-to-use, natural manner. The window environment can be thought of as an emulation of a desk. The analogy is that you are working on something that resides on the top of a pile of paper. If you are interrupted, new work is placed on that pile, covering up the work you were doing. When you finish with this new work, you move it off your desk and continue where you left off on the work you were doing before. This interruption and restoration of the working environment is the concept on which the window software metaphor is based.

This article illustrates the use of windows in the Forth environment. The window package I present here uses the F83 dialect of Forth developed by Laxen and Perry. The program is based upon and inspired by the article entitled "A Simple Window Package," by Edward Mitchell, which appeared in the January 1984 issue of *DDJ*. In addition to the primary topic of windows, I'll also discuss some other subjects, including MS-DOS memory management, manipulation of the IBM PC hardware, interfacing Forth to the PC's BIOS and BDOS, and Forth 8088 assembly language.

People with computers other than an IBM PC (or a true compatible) and people using other dialects of Forth may need to make some changes to the program in order to get it to work on their systems. The concepts presented in this Forth implementation of windows, however, can be applied to an implementation in any other computer language, including C or Pascal.

The program presented in Listing One, page 96, is basically a tool awaiting your use; it is meant to be integrated into an application program. The number of windows you can have on your display screen at one time is a function only of the amount of memory you have in your computer—you are not limited by the available memory in the 64K segment in which Forth is running. The demonstration program provided in the listing shows how to integrate an application (the demo itself) with the window routines.

Memory Management

It's important to understand how MS-DOS performs memory management if you are to understand how the window package works and why it isn't shackled by the 64K segment constraint imposed on the Forth system. Memory management is not necessary just because I'm using Forth for this program; it's necessary for any program, in any language, that uses more than 64K in its operation.

Upon receiving control from MS-DOS, an executable program is given all the memory available in your computer for its use, whether or not your program requires this much memory. Under these conditions MS-DOS cannot manage memory because there is none left to manage—it all belongs to your executable program. In order for MS-DOS to manage the memory, your program must give back to the operating system the memory it doesn't need. This is done by using the *setblock* function of MS-DOS. By informing MS-DOS of the total memory requirement of your program, your allocated memory block will shrink and the MS-DOS pool of free memory will be given the remainder of the available memory in your computer. This free pool of memory can then be managed for your uses by MS-DOS.

Three special words in the Forth window package deal with MS-DOS memory management. They are *setblock*, *calloc*, and *free*. *Setblock* shrinks the memory block allocated to the Forth program of which it is a part. The *setblock* word defined on screen 7 accepts as a parameter the number of bytes required by the application (the Forth system). It returns a true flag if the memory block size adjustment was successful, or it returns a false flag, error code, and the maximum number of 8088 paragraphs available if the adjustment was unsuccessful. The error codes correspond to those listed in the DOS manual.

In my window application, the word *initialize* calls *setblock* and passes it a −1 (FFFF hex) as the number of bytes to be set aside for Forth's

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use. In other words, Forth is given a full 64K segment in which to run, thereby excluding MS-DOS memory management from that area. Forth owns all of this 64K block.

After *setblock* gives MS-DOS some memory to manage, calls to the Forth word *calloc* cause MS-DOS to provide a memory area for your use. This memory area comes directly out of the free pool and belongs to the application until it is given back. The word *calloc* accepts as a parameter the number of bytes required for a new memory block. It returns a true flag and the 8088 segment address if successful, or it returns a false flag, error code, and maximum number of paragraphs available from the free pool, if the allocation fails.

Just as memory blocks are given out by MS-DOS, they can also be given back when an application has finished with them. The Forth word *free* performs that function in the window package. Any memory block that has been allocated previously can be released. The word *free* accepts the segment address of the block to be returned and returns either a true flag if successful or a false flag and error code if not.

You should keep two things in mind when dealing with MS-DOS memory management functions. First, a program should never write into any memory it does not explicitly own—for example, programs must be sure the stack is in an area of memory owned by the application. Second, never try to release memory that was not allocated by MS-DOS originally. Violating either of these rules can result in unexplained behavior on the part of your computer.

The memory management words used in this window program all make calls to MS-DOS *int 21h* using the appropriate function codes. MS-DOS performs the requests, if possible, and the Forth words pass back flags on the stack indicating the status of the requested operation.

Low-Level Assembly-Language Words

Approximately one third of all the Forth words in this window package are written in 8088 assembly language (see Tables 1 and 2, pages 47 and 48). There are two reasons for this. First, the F83 package used to develop this

chra   char/attrib count --
Writes (count) characters with attributes to the screen starting at the current cursor position. The cursor position is left unchanged. This word calls BIOS *int 10h* using function code *9* to perform its operation.

chra+   char/attrib --
Similiar to *chra* except only a single character with attribute is written and the cursor position is advanced automatically. BIOS *int 10h* is again used to first write the character and attribute and then to read and advance the cursor position.

rdchra   -- char/attrib
Calls BIOS *int 10h* with function code *8* to return the character and attribute of the character currently under the cursor.

scrlup   xul yul xlr ylr count attrib --
Scrolls up the area of the screen bounded on the upper left by *xul* and *yul* and on the lower right by *xlr* and *ylr.* The window is scrolled up (count) lines, and the blank lines scrolled in from the bottom are given attribute (attrib). If count is specified as *0*, the whole window is cleared.

calloc   # of bytes -- seg T -- max paragraphs error code F
Initiates a memory allocation request to MS-DOS. If the memory requested is available, the segment address and a true flag will be returned. If enough memory is not available, then an error code and a false flag are returned along with the maximum number of paragraphs available.

free   seg -- T -- error code F
Attempts to release to MS-DOS a block of memory previously allocated via *calloc* If successful, a true flag is returned. If unsuccessful, an error code and a false flag are returned.

setblock   # of bytes -- T -- max paragraphs error code F
Asks MS-DOS to shrink or expand the unassigned memory until the application program has the number of bytes requested for its use. If the operation is successful, a true flag is returned. If not, an error code and a false flag are returned, along with the maximum number of paragraphs available.

e@   seg addr -- n
Returns to the top of the parameter stack the data (*n*) at address (*addr*) in memory segment (*seg*). I call this word extended fetch because it has access to the complete memory space and not just the 64K segment in which Forth runs.

e!   n seg addr --
Stores the data (*n*) at address (*addr*) in memory segment (*seg*). I call this word extended store because it has access to the complete memory space and not just the 64K segment in which Forth runs.

rdcur   -- x y
Uses BIOS *int 10h* function code *3* to return the x,y location of the cursor.

save_h, save_w, save_ptr, save_si, save_ds   -- addr
These Forth words are used as temporary storage locations during the *scr->buf* and *buf->scn* routines. When executed, they return the address of a 2-byte storage area. The storage area *save_h* is used to save the height parameter, *save_w* the width parameter, *save_ptr* the address in screen memory to which data is to be saved or restored, *save_si* the 8088 *si* register that is used by Forth as the instruction pointer, and *save_ds* the data segment in which Forth is running.

scn->buf   x y width height seg --
Moves memory a word at a time from the appropriate position in the screen memory to a buffer defined by the seg parameter. Both the character and attribute residing on the screen at a given location are moved. X and y mark the upper-left corner of the rectangle to be moved.

buf->scn   seg x y width height --
Moves memory a word at a time from a buffer in memory defined by (*seg*) to the appropriate position in the screen memory. Both the character and attribute stored in this memory buffer are moved. X and y mark the upper-left corner of the rectangle to be restored.

Table 1: *Forth assembly-language word definitions*

FORTH WINDOWS
(continued from page 47)

software has limited BIOS/BDOS support for the special functions required. Second, assembly-language code executes faster than any higher-level language, including Forth.

Three different levels of software interface are used in this window package. The lowest level, which involves direct manipulation of the PC hardware, includes the words *buf->scn* and *scn->buf*. Both of these Forth words read and/or write to video RAM directly while saving and restoring of the display is taking place. Because of their direct manipulation of the video display, these words are also the least transportable. They must know whether they are running in a PC that has only a monochrome monitor or one with a graphics adapter. This is done by changing the value of the constant *v_seg* in the window program and recompiling. The correct values of *v_seg* are as follows:

color graphic adapter *v_seg* = B800h
monochrome monitor *v_seg* = B000h

The constant *v_seg* informs both *scn->buf* and *buf->scn* of where the video memory begins, and they do the rest. See the section on the save and restore algorithm for specifics on how these words work.

The next higher level of software interface to the PC makes use of the BIOS routines. In this program, extensive use is made of the functions provided by the video BIOS interrupt, *int 10h*. The video functions are accessed by placing parameters in the various 8088 registers, placing a function code in the *ah* register, and issuing the *int 10h* request. Table 3, page 50, gives a summary of which *int 10h* functions are used and where.

When using the BIOS functions, it's important to save any registers of special significance as many of the BIOS routines alter registers during the course of their operation. This version of Forth, for example, uses the 8088 *si* register as the instruction pointer and the *bp* register as the return stack pointer. These registers, therefore, must be saved and restored after any BIOS routines that modify them are used. In all the low-level word definitions that access the BIOS routines, you'll see *si push* and *si pop* instructions surrounding the BIOS interrupt call. You'll also find a *bp push* and *bp pop* in the *scrlup* word definition because the *bp* register is modified there.

The highest level of software interface is on the BDOS level. The memory management words *calloc, free,* and *setblock* are examples of this

case, of, endof, and *endcase*
Dr. Charles Eaker's *case* statement. See *Forth Dimensions*, vol. II, no. 3, p. 37 for details on how these words work.

putch x y char/attrib --
Writes the character and attribute onto the video display screen at location x,y. The cursor position is set at the next character.

getch x y -- char/attrib
Returns the character and attribute at location x,y on the video display screen. The cursor is moved automatically to position x,y.

draw_row x y char/attrib count --
Displays (count) identical characters starting at the position on the video display screen defined by x,y.

ulx, uly, width, height, curx, cury,
oldx, oldy, bufseg, oldwcbseg, attrib -- n
These words are constants that define the positions of storage locations within the current window control block (wcb). When executed, they return offsets relative to the start of the wcb storage area. (See Table 7.)

wcbseg! n addr --
Stores information into the active wcb. The active wcb is the one whose segment address is in the variable *wcbseg*. For example, *7 attrib wcbseg!* would store the display attribute 7 into the *attrib* slot in the active window control block. The *attrib* word supplies the address in which to store the display attribute.

wcbseg@ addr -- n
Fetches information from the active wcb. For example, *attrib wcbseg@* would fetch the display attribute from the active window control block and put it on the parameter stack.

top, sides, bottom --
These words draw the actual window frame on the display screen. When executed, they draw the top, sides, and bottom, respectively, of the window specified in the active wcb. The program constant *border* shown in the listing is used to determine the attribute with which to draw the window frame. The current version sets it to high-intensity normal video.

((window)) --
This is the lowest-level window routine. It automatically fetches from the current wcb the position and size of the window to be drawn on the display, copies to the appropriate window buffer the portion of the display screen that will be overwritten by this new window, and then draws the window frame by invoking *top, sides,* and *bottom.*

clr_window --
Clears the current window by fetching all the appropriate parameters from the wcb and invoking *scrlup* to clear the entire window. It then sets the window cursor position *curx, cury* to *0* to home the cursor in the window.

(window) x y width height attrib -- f
Builds the actual window. It tries to allocate enough memory to hold a new wcb (22 bytes). If successful, it links this new wcb into the wcb linked list and then tries to allocate enough memory to contain the screen information that the new window will overwrite. If this, too, is successful, all the parameters passed to this routine are stored in the new wcb, *((window))* is called to draw the actual window, and a true flag is returned to the calling program indicating that the creation of the window was successful. If either allocation attempt fails, the memory previously allocated is freed and a false flag is returned indicating win-

Table 2: *High-level Forth words*

BDOS interface. These words work by loading parameters into the 8088 registers, loading a function code into the *ah* register, and executing *int 21h*. All functions provided by *int 21h* save and restore all registers (except those used to pass back parameters), so the precautions used for the BIOS routine interface aren't required. Table 4, page 50, summarizes memory management functions performed via the BDOS interrupt.

dow creation failure. Under these conditions, an error message will be displayed to help the programmer find the source of the problem. In most cases a failure indicates lack of available memory.

open_window x y width height attrib -- f
This is the highest-level window word. Its function is to perform checking on the specified window parameters to verify validity. If the specified window wouldn't fit on the display screen, an appropriate error message will be displayed. Another error message will be displayed if the proper parameters are not present on the parameter stack. This word will not allow the programmer to create a window that cannot be displayed on the screen correctly.

close_window --
Closes the current window. A window is closed by moving the screen data stored in the memory buffer back onto the display screen, then freeing the memory allocated to both the wcb and the memory buffer. Next, the cursor is returned to where it was before this window was opened, and then the wcb is removed from the wcb linked list. If no windows are currently open, execution of this routine will result in an error message.

wat x y --
This routine (pronounced "window at") places the cursor in the window at the location specified by the x,y coordinates. These coordinates are relative to the current window, not the whole display screen. If either coordinate exceeds the size of the current window, the cursor will be placed as close as possible to the position specified without leaving the window.

rdwcur -- x y
Returns the cursor position relative to the current window.

rdwcha x y -- char/attrib
Returns the character and attribute found under the current window's cursor.

scroll_window --
Scrolls the current window up by one line to allow new information to be displayed. This word gets all the parameters it needs from the wcb. The attributes used for the blank line scrolled onto the display are the same as those specified when the window was created.

crout, lfout, bsout, bell --
These words perform, in the current window, the same function as they would perform if issued to the normal screen. Namely, they return the cursor to the first character position of the current line, move the cursor down one line, back the cursor up by one character position, and cause the computer to ring its chimes, respectively. Special versions of these functions are required to keep the cursor within the window.

wemit char --
This word (pronounced "window emit") is the equivalent of the Forth word *emit*. It should be used only when writing information to windows. In addition to sending normal characters to the display window, it performs the *cr, lf, bs,* and *bell* functions as described above. If a line feed (*lf*) character code is issued while the window cursor is on the last line of the window, *wemit* will scroll up all the information in the window accordingly.

initialize --
Sets up the MS-DOS memory management function. It requests a full 64K segment for the Forth system currently running. If this initialization is successful, an appropriate message is displayed and the *wcbseg* variable is set to *0*, indicating that no windows are currently active. If there wasn't enough memory, an error message is displayed and the window program is completely aborted.

Table 2 (continued): *High-level Forth words*

Forth 8088 Assembly Language

Assembly language in Forth is a bit unusual. The first conceptual hurdle that needs to be overcome involves the reverse Polish or postfix notion used throughout the assembly-language definitions. Assembly language written in this manner has the operand(s) preceding the mnemonics. For example, the standard 8088 assembly-language instruction *mov dh,dl*, where *dh* is the destination and *dl* is the source, is coded in Forth as *dh dl mov*.

Some new symbols are also necessary to allow the Forth assembler to create the correct instruction sequences. Special symbols used in this program are *#*, which indicates an immediate operand, and *#)*, which indicates an indirect operand. These symbols are sprinkled liberally throughout the low-level Forth code words.

A few other special-purpose Forth words are used in assembly-language definitions. The word *code* takes the name that follows it and creates a new dictionary entry for the code definition to follow and sets up certain pointers for Forth so that this code definition can be executed in a manner similiar to that of all Forth definitions. *Code* also tells the compiler to reference the assembler vocabulary so that all 8088 mnemonics that make up the definitions can be found in the dictionary searches and assembled into the code.

The word *next* (and its derivative *1push*) causes a direct jump back to the Forth inner interpreter. This restores control to the interpreter, which then passes control to the next Forth word in the program. Writing a code definition and forgetting to have *next* or *1push* as the final statement (before *end-code*) will cause your computer to crash right after the word is executed.

The word *1push* performs the same function as *next* does, except it pushes the contents of the 8088 *ax* register onto the parameter stack before returning to the inner interpreter. In this way, parameters can be passed back via the stack to subsequent high-level Forth definitions.

The final word *end-code* changes the vocabulary back to Forth (from assembler), performs a limited

(continued from page 49)

amount of error checking on the code definition, makes this new word visible in the dictionary, and then terminates the assembly-language word definition.

From the listing you can see how easily assembly-language word definitions can be integrated into a high-level Forth program. From my experience with in-line code written in any computer language, the following rules apply:

- Use in-line code only when speed of execution is required.
- Keep the definitions as small as is practical. This will aid in debugging and maintenance.
- Code carefully; errors in in-line code can send your computer on a journey from which it will never return except via reboot.

Screen Save and Restore Algorithm

The screen save and restore algorithm was developed to keep to a minimum the number of calculations necessary to locate the correct screen data and move it to/from buffers allocated for its storage. Minimal calculations result in the fastest possible execution of the windows.

All moves of data to or from the screen and buffers are word moves because the character and attribute for a screen character are stored in sequential bytes of screen memory. Character data is stored at even addresses, and attribute data is stored at odd addresses. When a word is fetched from an even addess in screen memory, the high byte contains the attribute and the low byte contains the actual character. For the same reason, sequential lines on the video display are offset not by 80 bytes but rather by 160 bytes. This fact is important whenever data is moved to or from the PC screen and is taken into consideration by the *scn->buf* and *buf->scn* word definitions.

A program design language (PDL) representation of the data movement algorithm is shown in Table 5, right. The start address of the video data needs to be calculated only once before the nested loops actually perform the work of moving the data. The 8088 block-move word instructions make the data movement from screen memory to buffer and from buffer back to screen memory a trivial task. The incrementing of the pointers shown in the PDL is handled automatically by specifying block-move word instructions. For both directions of data movement, the *ds:si* register pair points at the source of the data to move, and the *es:di* register pair points at the destination. Both *si* and *di* increment automatically by 2 for movement of word-size data.

Windows in Your Programs

Interfacing windows with your application program is relatively straightforward once you understand how the window package works. Once you have compiled the package, you can create windows interactively to see how they work before trying to use them in your program. For example, typing the commands

```
initialize 0 0 20 10 7 open_window
```

at the keyboard will immediately create a window with its upper-left corner at 0,0; a width of 20 characters; and a height of 10 vertical lines. (Width and height are inside dimensions of the windowed area; the bor-

Function	Function Code	Used in Forth Word(s)
write char with attribute	9	*chra, chra+*
get cursor position	3	*chra+, rdcur*
set cursor position	2	*chra+*
read char and attribute	8	*rdchra*
scroll up video window	6	*scrlup*

Table 3: *Summary of* int 10h *functions*

Function	Function Code	Used in Forth Word
allocate memory block	48h	*calloc*
release a memory block	49h	*free*
resize an allocated block	4ah	*setblock*

Table 4: *Memory management functions performed via the BDOS interrupt*

```
procedure scn->buf parameters are x, y, width, height and buf seg
begin
    set data movement direction to forward
    get buffer segment address into the extra segment reg.
    initialize destination ptr DI to 0 which points at the first byte of buffer storage
        in the buffer segment.
    save the height parameter in temporary storage
    save the width parameter in temporary storage
    get y coordinate of first location to store
    multiply by 160 to find line start address
    get x coordinate of first location to store
    multiply by 2 to find character address offset
    add new x and new y to get start address of data move
    save result in a temporary location called save_ptr
    save the current value of the SI register in a safe place
    save the current value of the DS register in a safe place
    move video segment address v_seg into the DS register
    do height times
        do width times
            move DS:SI to ES:DI  (move actual data)
            increment SI and DI both by 2 for word moves
        enddo
        save_ptr = save_ptr + 160  (move down 1 vertical line)
    enddo
    restore previous DS register value
    restore previous SI register value
    jump to next   (back to inner interpreter)
end
```

Table 5: *PDL representation for the data movement algorithm*

der of the window will take up two more characters horizontally and two lines vertically.) The attribute code of 7 will create the window using normal, low-intensity video. Remember, the word *initialize* is needed to set up the MS-DOS memory manager. If *initialize* is not executed before the *open_window* request, the request will fail.

Once a window is opened, you can move the window's cursor to any position by using the word *wat* (the window counterpart of the Forth word *at*). You can write text into the window using *wemit* and *wtype* (the window counterparts of *emit* and *type*). The special video control codes shown in Table 6, below, are also supported via *wemit*. Note that by redefining the F83 deferred word *emit* to *wemit*, you can get Forth to run in one of its own windows.

All words that write text into a window (such as *wemit*) always work on the currently selected window only [the window at the end of the window control block (wcb) linked list whose wcb address is contained in the Forth variable *wcbseg*]. Thus, continuing with the example, if you were to open a second window, *wemit* would then automatically write to this new window. The previous window could not be written to again until the new window was closed. The Forth word *close_window* closes the current window and reopens the previous window if one exists. If *close_window* is executed when no windows are open, an error message is displayed. A window that is closed erases itself from the screen (by restoring the screen data that it covered up), frees the memory it had allocated for the window control block and the screen buffer, and finally unlinks itself from the wcb list. Table 7, below, shows the structure of an entry in the wcb list.

The demo program in the listing is an example of how an application program can be integrated with the basic window package. It demonstrates opening windows using various attributes, writing text to the windows, using the special video control codes, listing Forth screens in a window, linking overlapping windows, clearing windows, and closing them. It illustrates how easy to use and how fast the windows can be.

DDJ

(Listing begins on page 96.)

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Video Code	Function
7	Ring the PC's bell
8	Backspace the window cursor
10	Linefeed (scroll upwards if necessary)
13	Carriage return

Table 6: *Video control codes*

Displacement	Name	Description
+ 0	ulx	X coordinate of upper left corner
+ 2	uly	Y coordinate of upper left corner
+ 4	width	Width of the window
+ 6	height	Height of the window
+ 8	curx	Window—relative cursor position
+10	cury	Window—relative cursor position
+12	oldx	Cursor position in previous window
+14	oldy	Cursor position in previous window
+16	bufseg	Points to window's text buffer
+18	oldwcb	Points to previous wcb record (NIL for last record)
+20	wattrib	Window's text attribute byte

Table 7: *Structure of an entry in the window control block list*

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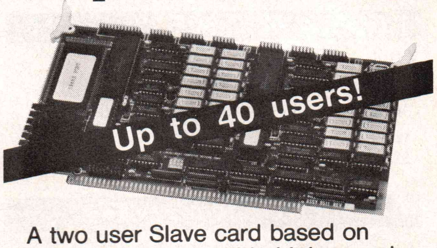

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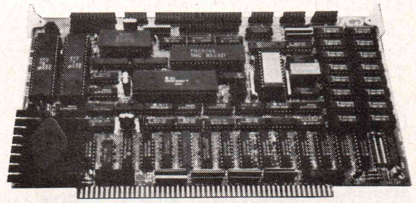

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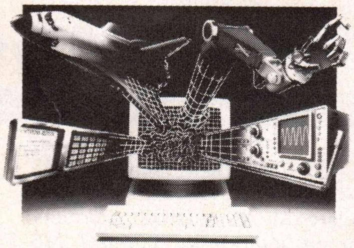

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B PROTOCOL

Listing Five (continued from June)

```
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            dseg
Timer                   dw        ?
Old_Second              db        ?
            endds

            pseg

            public      Start_Timer

Start_Timer proc
            push        BP
            mov         BP,SP
            mov         AX,[BP+4]             ; Get the number of seconds
            mov         Timer,AX
            mov         AX,2C00H
            int         21H                            ; Get current time
            mov         Old_Second,DH
            pop         BP
            ret
Start_Timer endp

            public      Timer_Expired

Timer_Expired proc
            mov         AX,2C00H
            int         21H                            ; Get current time
            cmp         DH,Old_Second                  ; Has the clock ticked?
            je          Timer_Expired_1                ; No
            mov         Old_Second,DH                  ; Yes, update Old_Second
            dec         Timer
            cmp         Timer,0
            jle         Timer_Expired_2                ; Timer expired?

Timer_Expired_1:
            xor         AX,AX                          ; No, return "false"
            ret

Timer_Expired_2:
            mov         AX,1                           ; Yes, return "true"
            ret
Timer_Expired endp

            endps
            end
```

End Listing Five

Listing Six

```
#define Loops_Per_Millisecond            9

Delay(N)
/**
 * Delay for N milliseconds
 **/
    int N;
{
    long K;

    for (K = Loops_Per_Millisecond * (long) N; K > 0; K--);
}
```

End Listing Six

Listing Seven

```
        page      57,132
        title     FileIO
;++
; FACILITY: DTE
;
; ABSTRACT:
;
;       This module contains the interface routines to the MS-DOS file
;       service.  All disk operations are done thru this module.
;
; ENVIRONMENT: MS-DOS, V2.0 or later
;
; AUTHOR: Steve Wilhite, CREATION DATE: 8-May-85
;
; REVISION HISTORY:
;
;--
        include   \lc\dos.mac
        pseg
```

```
@ab = 4                                          ; argument base
        page
        public    Create_File

Create_File proc near
;+
; Functional Description:
;
;       Creates a new file or truncates an old to zero length in
;       preparation for writing.
;
; Calling Sequence:
;
;       handle = Create_File(pathname, attribute)
;
; Parameters:
;
;       pathname  ptr to ASCIZ pathname
;       attribute file attribute(s)
;
; Return Value:
;
;       -5        access denied
;       -4        too many open files
;       -3        path not found
;       else      file handle number
;-
Pathname  equ     @ab[BP]
Attribute equ     @ab+2[BP]

        push      BP
        mov       BP,SP
        mov       DX,Pathname
        mov       CX,Attribute
        mov       AH,3CH
        int       21H
        jnc       Create_1
        neg       AX
Create_1:
        pop       BP
        ret
Create_File endp
        page
        public    Open_File

Open_File proc    near
;+
; Functional Description:
;
;       Opens a file.
;
; Calling Sequence:
;
;       handle = Open_File(pathname, access)
;
; Parameters:
;
;       pathname  ptr to ASCIZ pathname
;       access              access code (0 = read, 1 = write, 2 = read and write)
;
; Return Value:
;
;       -12       invalid access
;       -5        access denied
;       -4        too many open files
;       -2        file not found
;       >0        file handle number
;-
Access            equ     @ab+2[BP]

        push      BP
        mov       BP,SP
        mov       AH,3DH
        mov       DX,Pathname
        mov       AL,Access
        int       21H
        jnc       Open_1
        neg       AX
Open_1: pop       BP
        ret
Open_File endp
        page
        public    Close_File

Close_File proc   near
;+
; Functional Description:
;
;       Closes the file associated with a specified file handle.
;
; Calling Sequence:
;
;       status = Close_File(handle)
;
; Parameters:
;
;       handle              file handle for file to close
;
```

(continued on next page)

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B PROTOCOL

Listing Seven (listing continued)

```
; Return Value:
;
;           -6          invalid handle
;           0           no error
;-
Handle                  equ       @ab[BP]

            push        BP
            mov         BP,SP
            mov         AH,3EH
            mov         BX,Handle
            int         21H
            jnc         Close_1
            neg         AX
            jmp         Close_2
Close_1:
            mov         AX,0
Close_2:
            pop         BP
            ret
Close_File endp
            page
            public      Read_File

Read_File proc          near
;+
; Functional Description:
;
;           Transfers a specified number of bytes from a file into a buffer
;           location.  If the returned value for number of bytes read is
;           zero, then the program tried to read from the end of file.
;
; Calling Sequence:
;
;           bytes_read = Read_File(handle, buffer, bytes_to_read)
;
; Parameters:
;
;           handle              file handle for the file to read
;           buffer              ptr to buffer
;           bytes_to_read       number of bytes to read
;
; Return Value:
;
;           -6          invalid handle
;           -5          access denied
;            0          end of file
;           >0          number of bytes actually read
;-
Buffer                  equ       @ab+2[BP]
Count                   equ       @ab+4[BP]

            push        BP
            mov         BP,SP
            mov         AH,3FH
            mov         BX,Handle
            mov         CX,Count
            mov         DX,Buffer
            int         21H
            jnc         Read_1
            neg         AX
Read_1:     pop         BP
            ret
Read_File endp
            page
            public      Write_File

Write_File proc         near
;+
; Functional Description:
;
;           Transfers a specified number of bytes from a buffer into a file.
;           If the number of bytes written is not the same as the number
;           requested, then an error has occurred.
;
; Calling Sequence:
;
;           status = Write_File(handle, buffer, bytes_to_write)
;
; Parameters:
;
;           handle              file handle for file to write
;           buffer              ptr to buffer
;           bytes_to_write      number of bytes to write
;
; Return Value:
;
;           -6          invalid handle
;           -5          access denied
;           else        number of bytes written
;-
            push        BP
            mov         BP,SP
```

```
        mov     AH,40H
        mov     BX,Handle
        mov     CX,Count
        mov     DX,Buffer
        int     21H
        jnc     Write_1
        neg     AX
Write_1:
        pop     BP
        ret
Write_File endp

        public  Move_To_EOF

Move_To_EOF proc
        push    BP
        mov     BP,SP
        mov     AX,4202H
        mov     BX,4[BP]                ; file handle
        xor     CX,CX
        xor     DX,DX
        int     21H
        pop     BP
        ret
Move_To_EOF endp

        endps
        end
```

End Listing Seven

Listing Eight

```
        Title   Serial

        include \lc\dos.mac
        pseg
;+
; Table of Contents:
;-
public  Open_Modem
public  Read_Modem
public  Write_Modem
public  Close_Modem
public  Send_Break

        dseg
Comm_Params equ this byte
        db      11H                     ; XON
        db      13H                     ; XOFF
        db      ?                       ; Baud rate code
        db      0                       ; Parity = none
        db      1                       ; Word length = 8
        db      0                       ; stop bits = 1
        endds

        extrn   AS_Init:near            ; Initialize
        extrn   AS_Set_Mode:near  ; Set XON/XOFF mode
        extrn   AS_Set_Port:near  ; Initialize the port
        extrn   AS_Open:near            ; Open the port
        extrn   AS_IReady:near          ; Test input status
        extrn   AS_IChar:near           ; Input character
        extrn   AS_OReady:near          ; Test output status
        extrn   AS_OChar:near           ; Output character
        extrn   AS_Send_Break:near ; Send a break signal
        extrn   AS_OIdle:near           ; Test output idle status
        extrn   AS_Close:near           ; Close the comm port
        extrn   AS_Term:near            ; Terminate async I/O

;+
; Function:
;       Open the comm port.
;
; Calling Sequence:
;
;       Open_Modem(Port, Rate, Auto_XOFF)
;
; Parameters:
;       Port: 0 = COM1, 1 = COM2
;
;       Rate:   0       110 baud
;               1       300
;               2       450
;               3       1200
;               4       1800
;               5       2400
;               6       4800
;               7       9600
;
;       Auto_XOFF: if true, enable auto XOFF/XON flow-of-control
;-
Open_Modem proc
        push    BP
        mov     BP,SP
        mov     AX,4[BP]                ; Get port number
```

(continued on next page)

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B PROTOCOL

Listing Eight (listing continued)

```
         call     AS_Init                          ; Initialize async
         mov      AX,8[BP]              ; Get XOFF/XON flags
         cmp      AX,0                             ;
         je       Init_1
         mov      AX,3
Init_1:
         call     AS_Set_Mode                      ; Set them
         mov      AL,6[BP]              ; Get baud rate code
         mov      Comm_Params[2],AL     ; and store
         mov      SI,offset Comm_Params
         call     AS_Set_Port                      ; Initialize the port
         call     AS_Open                          ; Open the comm port
         pop      BP
         ret
Open_Modem endp

;+
; Function:
;        Read a character from the comm port.
;
; Calling Sequence:
;
;        ret_value = Read_Modem()
;
; Returns:
;        -1 if no character is available; otherwise the character.
;-
Read_Modem proc
         call     AS_IReady             ; Test input status
         cmp      AX,-1                            ; Ready?
         jne      Read_1                           ; Yes
         ret                                       ; No, return -1

Read_1:
         call     AS_IChar              ; Input character
         mov      AH,0
         ret
Read_Modem endp


;+
; Function:
;        Write a character to the comm port.
;
; Calling Sequence:
;
;        status = Write_Modem(Char)
;
; Returns:
;        0 if could not send the character; otherwise -1
;-
Write_Modem proc
         push     BP
         mov      BP,SP
         call     AS_OReady             ; Test output status
         not      AX
         cmp      AX,0                             ; Ready?
         je       Write_1                          ; No, return failure
         mov      AX,[BP+4]             ; Get character to send
         call     AS_OChar              ; Send it
         mov      AX,-1                            ; Success

Write_1:
         pop      BP
         ret
Write_Modem endp


;+
; Function:
;        Close the comm port.
;
; Calling Sequence:
;
;        status = Close_Modem()
;
; Returns:
;-
Close_Modem proc
Close_1:
         call     AS_OIdle              ; Test output idle status
         cmp      AX,0                             ; Done?
         jne      Close_1                          ; No
         call     AS_Close
         call     AS_Term
         ret
Close_Modem endp

;+
; Function:
;        Send a break "character" to the comm port.
```

```
;
; Calling Sequence:
;
;         Send_Break();
;-
Send_Break proc
        mov     AX,50                   ; milliseconds
        call    AS_Send_Break
        ret
Send_Break endp

        endps
        end
```

End Listing Eight

Listing Nine

```
        title   Break
        include \lc\dos.mac
        pseg

        public  Set_Break, Get_Break

Set_Break proc
        push    BP
        mov     BP,SP
        mov     DL,4[BP]        ; Get state to set
        mov     AX,3301H
        int     21H
        pop     BP
        ret
Set_Break endp


Get_Break proc
        mov     AX,3300H
        int     21H
        mov     AL,DL
        xor     AH,AH
        ret
Get_Break endp

        endps
        end
```

End Listings

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Listing One (Text begins on page 8.)

```
;Listing 1 - Square root algorithm plus code to benchmark and test it.
;
INT_ROOT  SEGMENT
                ASSUME  CS:INT_ROOT
;
CALC_ROOT PROC     NEAR
;---------------------------------------------;
; Argument passed in BX.                      ;
; Root returned in BX.                        ;
; All registers except BX preserved.          ;
;---------------------------------------------;
                PUSH      AX
                PUSH      CX
                MOV       AX,BX                     ;Hold argument in AX.
                OR        BH,BH
                JNZ       GE_256
                CMP       BL,1                      ;If arg is zero or one,
                JBE       GOT_ROOT ;then root = argument.
                MOV       CL,4                      ;If 2 <= argument <= 255
                SHR       BL,CL                     ;then guess = 3 + arg/16.
                ADD       BL,3
                JMP SHORT NEWTON
GE_256:         MOV       BL,BH
                MOV       BH,0
                JS        GE_32768
                CMP       BL,16
                JAE       GE_4096
                SHL       BL,1                      ;If 256 <= argument <= 4095
                SHL       BL,1                      ;then guess=13+4*(arg hi byte).
                ADD       BL,13
                JMP SHORT NEWTON
GE_4096:  ADD   BL,50                ;If 4096 <= argument <= 32767
                JMP SHORT NEWTON     ;then guess = 50 + arg hi byte
GE_32768: CMP   BL,255       ;If arg hi byte=255 then root=255.
                JZ        GOT_ROOT ;This prevents ovflow by DIV.
                ADD       BL,40                     ;If 32768 <= argument <= 65279
                JNC       NEWTON                    ;then guess = 40 + arg hi byte.
                MOV       BL,255                    ;Guess must never exceed 255.
;
NEWTON:         MOV       CX,AX                     ;Save argument in CX.
                DIV       BL                        ;Divide by guess.
                ADD       BL,AL                     ;Guess + quotient.
                RCR       BL,1                      ;New guess=(old guess+quot)/2.
                MOV       AL,BL                     ;RCR shifts in carry from ADD.;
                MUL       AL                        ;If the square of the new guess
                CMP       AX,CX                     ;is greater than the argument,
                JBE       GOT_ROOT  ;then we decrement new guess
                DEC       BX                        ;to get the correct root.
;
GOT_ROOT: POP   CX
                POP       AX
                RET
;
CALC_ROOT ENDP
;
;Listing 1 - Continued.
;-------------------------------------------------------------;
; Code to time and test CALC_ROOT is designed to be run under;
; DEBUG and does not do a normal return to DOS but instead   ;
; does an INT 3 at the end of each routine.                   ;
;-------------------------------------------------------------;
TIME            PROC      FAR
;-------------------------------------------------------------;
; TIME_ROOT computes the root of each of 65536 possible      ;
; arguments 15 times for a total of 983,040 roots.            ;
; TIME_OVER represents the looping overhead in TIME_ROOT.     ;
; The difference between the two times is the time to call   ;
; and execute CALC_ROOT.                                      ;
;-------------------------------------------------------------;
                MOV       BP,15
TIME_OVER:      MOV       SI,0                      ;Initial value.
INNER_OVR:      MOV       BX,SI
                INC       SI
                JNZ       INNER_OVR
                DEC       BP
                JNZ       TIME_OVER
END_OVER: MOV   AH,2
                MOV       DL,7                      ;Beep speaker.
                INT       21H
                INT       3
;
                MOV       BP,15
TIME_ROOT:      MOV       SI,0                      ;Initial value.
INNR_ROOT:      MOV       BX,SI
                CALL      CALC_ROOT
                INC       SI
                JNZ       INNR_ROOT
                DEC       BP
                JNZ       TIME_ROOT
END_TIME: MOV   AH,2
                MOV       DL,7                      ;Beep speaker.
                INT       21H
                INT       3
;
TIME            ENDP
```


(continued on page 62)

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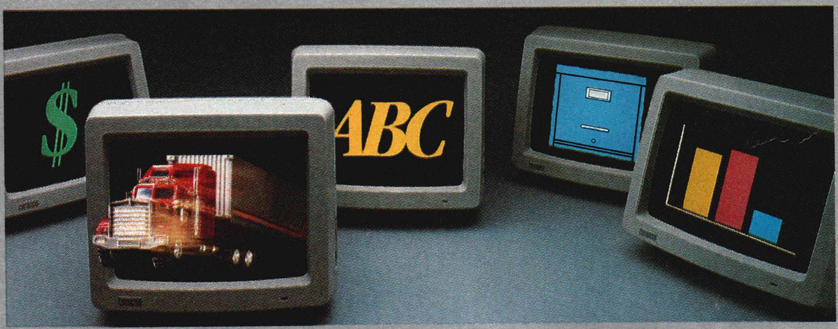

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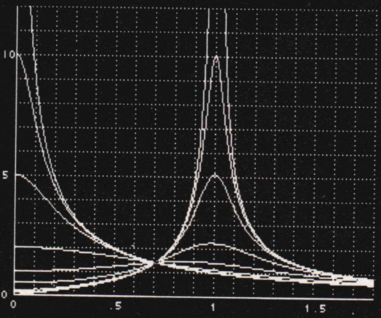

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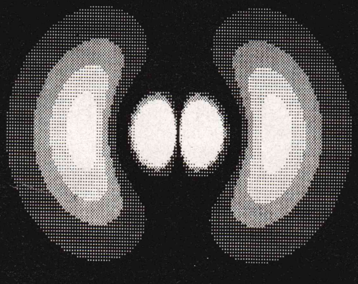
BASIC 213 sec   ISYS FORTH 20 sec



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Listing One (Listing continued, text begins on page 8.)

```
;
;Listing 1 - Continued.
;
TEST                PROC      FAR
;-----------------------------------------------------------;
; If CHK_ROOT detects a bad root, it displays a message and  ;
; leaves the NG root in BX and the argument in SI.           ;
; If all roots are OK, a message to this effect is displayed.;
;-----------------------------------------------------------;
                    MOV       SI,0            ;Initial value.
CHK_ROOT: MOV       BX,SI
                    CALL      CALC_ROOT
                    MOV       AX,BX
                    MUL       AX              ;DX,AX contains root^2.
                    JO        NG_ROOT         ;NG if root ^2 > 65535.
                    CMP       AX,SI
                    JA        NG_ROOT         ;NG if root^2 > argument.
                    MOV       AX,BX
                    INC       AX
                    MUL       AX              ;DX,AX contains (root+1)^2.
                    JO        NEXT_ARG ;If ovflow then OK.
                    CMP       AX,SI
                    JBE       NG_ROOT         ;NG if (root+1)^2 <=argument.
NEXT_ARG: INC       SI
                    JNZ       CHK_ROOT
                    JMP SHORT OK_ROOTS
;
OK_MSG    DB  0DH,0AH,'All roots tested OK.',0DH,0AH,'$'
NG_MSG  DB  0DH,0AH,'Bad root in BX. Arg in SI.',0DH,0AH,'$'
;
OK_ROOTS; MOV       DX,OFFSET OK_MSG+100H     ;DS points to Pgm Seg
                    JMP SHORT DO_MSG          ;Pref which is 100H
NG_ROOT:  MOV       DX,OFFSET NG_MSG+100H     ;lower than code seg.
;
DO_MSG:             MOV       AH,9            ;Print string.
                    INT       21H
                    INT 3                     ;Back to DEBUG.
;
TEST                ENDP
;
INT_ROOT  ENDS
;
                    END       TEST
```

End Listing One

Listing Two

```
;Listing 2 - BASIC program to test if a formula makes good square root guesses.

10 FOR I = 2 TO 256
20 Q = I*I - 1
30 '
40 'Trial Formula to Calculate P0.
50 '
60 QHI = INT(Q/256): QLO = Q-QHI*256
70 IF QHI = 0 THEN P0 = INT(QLO/32) + 3: GOTO 160
80 IF QHI < 16 THEN P0 = 13 + 4*QHI: GOTO 160
90 IF QHI < 128 THEN P0 = QHI + 50; GOTO 160
100 IF QHI = 255 THEN P1 = 255: GOTO 210
110 P0 = QHI + 40
120 IF P0 > 255 THEN P0 = 255
130 '
140 ' Newtons Method
150 '
160 P1=INT((P0 + INT(Q / P0)) / 2)
170 IF P1 > 255 THEN PRINT "P1 > 255 when Q = ";Q:END
180 '
190 'Test result
200 '
210 P = INT(SQR(Q))
220 IF P1 <= P+1 GOTO 240
230 PRINT "For Q = ";Q;" P1 is greater than P+1. ":END
240 NEXT I
250 PRINT "Formula works for all worst cases."
```

End Listing Two

Listing Three

```
Listing Three

 INCLUDE MACLIB.ASM          ;by Neil R. Koozer
 LIST ON                     ;   Kellogg Star Rt. Box 125
 MACLIST OFF                         ;   Oakland, OR 97462
;                                         (503)-459-3709
;SQR.ASM

;Note that words like BR1 and BFS1 are macros to emulate BR:B and BFS:B

GLOBAL SQR

SQR                   ;square root function for 32000 floating point
 RESTORE [R0]             ;use ret. addr as a pointer
 MOVD 0(R0),R1        ;get operand address
 MOVD 0(R1),R6        ;get part of operand
 MOVD 4(R1),R7        ;get other part of operand
 SBITB 31,R7          ;make the implicit 1 explicit
```


(continued on page 66)

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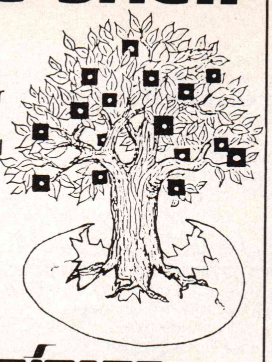

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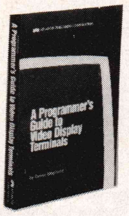

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Listing Three **(Listing continued, text begins on page 8.)**

```
 MOVD R6,R1           ;get exponent
 ANDW 7FFH,R1         ;clean exponent
 ADDW 3FFH,R1         ;fix offset
 ROTW -1,R1           ;div exp by 2
 CBITB 15,R1          ;test & clear wrap-around bit, 1=odd 0=even
 SAVE [R0,R1]         ;save exp & ret addr
 MOVB R7,R6           ;prepare for right shift
 BFS1 SQR1            ;jump if exponent was odd
 LSHD -4,R7           ;shift -3 for safety & -1 to get halfx
 ROTD -4,R6
 ANDW FF80H,R6        ;remove non-mantissa bits
 MOVD 4C1BF828H,R3    ;y seed = 1.189.../2
 BR1 SQR2
SQR1
 LSHD -3,R7           ;shift -3 for safety, -1 to get halfx, +1 because
 ROTD -3,R6           ;  orig exp was odd
 ANDW FF00H,R6        ;remove non-mantissa bits
 MOVD 6A227E65H,R3    ;y seed = 1.68.../2

SQR2                  ;We will do 3 iterations with 32-bit precision
 MOVD R7,R5           ;get halfx into R5
 DEID R3,R4           ;R5 = halfx/y0  (the junk in R4 doesn't matter)
 LSHD -1,R3           ;R3 = y0/2
 ADDD R5,R3           ;R3 = new y0

 MOVD R7,R5           ;second iteration
 DEID R3,R4
 LSHD -1,R3
 ADDD R5,R3

 MOVD R7,R5           ;third iteration
 DEID R3,R4
 LSHD -1,R3
 ADDD R5,R3


 MOVD R6,R4           ;Now the final iteration at full precision
 MOVD R7,R5           ;get R4R5 = halfx from R6R7

 DEID R3,R4           ;now divide halfx (R4R5) by y (R2R3)
 MOVD R2,R0
 MEID R5,R0
 NEGD R0,R0
 SUBCD R1,R4
 MOVD R4,R1
 BCC1 DIV1
DIV2
 ADDQD -1,R5
 ADDD R2,R0
 ADDCD R3,R1
 BCC DIV2
DIV1
 DEID R3,R0
 MOVD R1,R4           ;R4R5 now = halfx / y

 MOVB R3,R2
 LSHD -1,R3
 ROTD -1,R2           ;R2R3 = y/2

 ADDD R4,R2
 ADDCD R5,R3          ;R2R3 = y/2 + halfx/y
                      ;4th iteration complete

 RESTORE [R0,R1]      ;get exponent & ret. addr
 ADDD R2,R2           ;shift mantissa back where it belongs
 ADDCD R3,R3
 BCC1 SQR4            ;there should almost never be a carry
 MOVB R3,R2
 LSHD -1,R3           ;undo that last shift & zero the MSbit
 ROTD -1,R2
 ADDQW 1,R1           ;adjust exponent
 BR1 SQR5             ;done
SQR4
 CBITB 31,R3          ;test & clear MSbit (make it a + sign)
 BFS1 SQR5            ;it would virtually always be a 1
 ADDD R2,R2           ;if not, shift left again
 ADDCD R3,R3
 ADDQW -1,R1          ;adjust exponent
 CBITB 31,R3          ;make it +
SQR5
 ANDW F800H,R2        ;clean the mantissa
 ORW R1,R2            ;append the exponent

 MOVD 4(R0),R1        ;get addr of destination variable
 MOVD R2,0(R1)        ;store result in dest. variable
 MOVD R3,4(R1)
 JUMP 8(R0)           ;return to caller

 END
```

End Listings

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C CHEST

Listing One (Text begins on page 18.)

```
                    Listing 1 -- tree.c
----------------------------------------------------------------------------
#include <stdio.h>

/*      TREE.C: Various binary tree routines:
 *
 *              (C) 1986, Allen I. Holub.  All rights reserved.
 */

typedef struct _n
{
        struct _n    *left;
        struct _n    *right;
        char         *key;
}
LEAF;

char            *Map;
extern  char    *makebitmap();

/*----------------------------------------------------------------------
 * These defines are used by the lr_trav() routine:
 */

#define mark(p)         ( *( (p)->key )  |=  0x80 )
#define marked(p)       ( *( (p)->key )  &   0x80 )
#define unmark(p)       ( *( (p)->key )  &= ~0x80 )
#define visit(root)     printf("%s ", root->key );

/*----------------------------------------------------------------------*/

tree( key, rootp )
char    *key;
LEAF    **rootp;        /* POINTER to (not the contents of) the root    */
{
        /* Non-recursive binary tree search and insert function. If key
         * is in the tree a message to that effect is printed, otherwise
         * a node containing key is inserted into the tree at the
         * proper place.
         */

        LEAF    *root          = *rootp ;
        LEAF    **insert_here =  rootp ;
        LEAF    *malloc();
        int     rel;

        while( root )
        {
                if( (rel = strcmp(key, root->key)) == 0 )
                {
                        printf("key <%s> in tree\n", key );
                        return;
                }
                else
                {
                        insert_here = (rel < 0) ? &root->left : &root->right ;
                        root = *insert_here ;
                }
        }

        if( *insert_here = root = malloc(sizeof(LEAF)) )
        {
                root->right = root->left = NULL;
                root->key   = key;
        }
        else
                printf("Out of memory.\n");
}

/*----------------------------------------------------------------------*/

sinorder( root )
LEAF    *root;
{
        /* A simple recursive in-order traversal, each node is printed
         * with as many tabs to it's left as it is deep in the tree.
         * (if a node is at depth 4 then 4 tabs are printed).
         */

        static int      depth = -1;
        register int    i;

        if( root )
        {
                depth++;

                inorder( root->left );
                for(i = depth; --i >= 0 ; putchar('\t') )
                        ;

                printf( "%s\n", root->key );
                inorder( root->right );
```

```
                depth--;
        }
}

/*----------------------------------------------------------------------
 * inorder():
 *
 * Does an recursive in-order traversal of a binary tree, printing
 * it in graphic form (showing the various pointers). Note that
 * the traverse order is reversed (go right, print root, go left)
 * so that a mirror image of the tree won't be printed (normal
 * traversal would result in the leftmost node of the left subtree
 * being printed first).
 *
 *     | is associated with this depth in the bitmap:
 *          1       2       3
 *          |       |       |
 *          V       V       |
 *                          V
 *          +---1---+
 *          |       |       +---2
 *          |       +---2---+
 *     0---+                        Node number == depth in tree.
 *          |       +---2
 *          +---1---+
 *                  +---2
 */

inorder( root, amleft )
LEAF    *root;          /* Root of current subtree                      */
int     amleft;         /* Root is a left decendant of the parent       */
{
        static int      depth = -1;     /* Current depth in the tree    */
        int             i;

        if( root )
        {
                ++depth;

                if( root->right )
                        inorder( root->right, 0 );
                else
                        setbit( depth+1, Map, 1 );

                for(i = 1; i <= depth ; i++ )
                {
                        printf( i == depth      ? "    +---" :
                                testbit(i,Map)  ? "    |   " :
                                                  "        " );
                }

                printf( "%s%s\n", root->key,
                                root->left || root->right ? "---+" : "" );

                setbit( depth, Map, amleft ? 0 : 1 );

                if( root->left )
                        inorder( root->left, 1 );
                else
                        setbit( depth+1, Map, 0 );

                --depth;
        }
}


/*----------------------------------------------------------------------*/


pline( depth )
{
        int     i;
        for(i = 0; i < depth-1 ; i++ )
                printf( testbit(i,Map) ? "|       " : "        " );
}

/*- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -*/

preorder( root, amright )
LEAF    *root;
{
        /* Does a recursive pre-order traversal of a binary tree printing
         * the tree in graphic form. Though this routine is interesting,
         * it is more useful when adapted to multi-way tree traversal
         * for use in such aplications a printing directory trees.
         */

        static int      depth = -1;

        if( root )
        {
                pline( ++depth );
                printf( "%s%s\n", depth ? "+-------" : "" , root->key );

                if( root->right )
```

(continued on next page)

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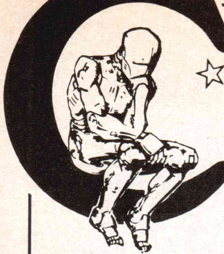

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C CHEST

Listing One (Listing continued, text begins on page 18.)

```
                        setbit( depth, Map, 1 );

                preorder( root->left,  0 );
                setbit  ( depth, Map,  0 );
                preorder( root->right, 1 );

                if( amright && !(root->right || root->left) )
                {
                        pline( depth );
                        printf("\n");
                }

                depth--;
        }
}

/*----------------------------------------------------------------------
 * lr_trav() (below) does a non-recursive link-reversal traversal of a
 * binary tree. The algorithm used is:
 *
 * do forever
 *      if( marked( pres ) )
 *              clear mark
 *      else
 *              while( there's a left child )
 *                      preorder visit
 *                      go left
 *
 *              inorder & preorder visit
 *
 *      postorder visit
 *
 *      if( no previous node )
 *              break
 *
 *      if( marked( prev ) )
 *              go up from a right child
 *      else
 *              go up from a left child
 *              inorder visit
 *              set mark
 *              go right
 *
 *   "Go" means to decend one node in the tree, reversing the pointer
 *   to that node so that it points back up where we came from.
 *   If we "go left" then we reverse the the left pointer;
 *   if we "go right" then right pointer is reversed. "Go up" means
 *   return to the previous node and make the pointer point back to
 *   its original location. A node is marked after we have
 *   traversed its left sub-tree. The mark is cleared after we've
 *   traversed both the left and right sub-trees. The high bit of
 *   the "key" field is used to mark the node, you could also add
 *   another field to the structure if you have a numeric key. Only
 *   one bit is needed for the mark.
 */

lr_trav( pres )
LEAF  *pres;
{
        LEAF    *prev = NULL, *next;

        while( 1 )
        {
                if( marked(pres) )
                        unmark( pres );
                else
                {
                        while( next = pres->left )
                        {
                                /* preorder visit */
                                /* goes here      */

                                pres->left = prev;      /* go left        */
                                prev       = pres;
                                pres       = next;
                        }
                        visit( pres );                  /* inorder & pre- */
                                                        /* order visit    */
                }

                /* postorder visit goes here */

                if( !prev )
                        break;

                if( marked(prev) )
                {
                        next        = prev->right;      /* go up from a */
                        prev->right = pres;             /* right child  */
                        pres        = prev;
                        prev        = next;
```

```
                }
                else
                {
                        next      = prev->left;         /* go up from a */
                        prev->left = pres;              /* left child   */
                        pres      = prev;
                        prev      = next;

                        visit( pres );                  /* inorder visit */

                        mark( pres );                   /* mark the node */
                        if( next = pres->right )        /* go right      */
                        {
                                pres->right = prev;
                                prev        = pres;
                                pres        = next;
                        }
                }
        }

        printf("\n");
}

/*-------------------------------------------------------------------*/

main(argc, argv)
char    **argv;
{
        static LEAF     *root = NULL ;
        char            buf[128];

        Map = makebitmap( 128 );

#ifdef MODEL
        for( printf("? "); gets(buf); printf("? ") )
        {
                tree( strsave(buf), &root );
                lr_trav ( root );
                inorder ( root , 0 );
                preorder( root , 0 );
        }
#endif

        while( --argc > 0 )
                tree( *++argv, &root );

        inorder ( root , 0 );
}
```

End Listing One

Listing Two

```
                        Listing 2 -- bitmap.c
-----------------------------------------------------------------------
/*      BITMAP.C        makebitmap, setbit, testbit: bit map manipulation
 *                      routines.
 *
 *      Copyright (c) 1985,1986     Allen I. Holub, all rights reserved.
 *
 *      These routines originally appeared in the June, 1985, C Chest (DDJ
 *      #104). They are reproduced here in a stripped-down version.
 *      Please see that column for more information about how they work.
 */

extern char     *calloc         ( unsigned, unsigned );

typedef char BITMAP;

/*-------------------------------------------------------------------*/

BITMAP    *makebitmap( size )
unsigned  size;
{
        /*  Make a bit map for "size" bits.                          */
        /*  Return a pointer to the map or NULL if we couldn't make it. */

        unsigned *map, numbytes;

        numbytes = (size >> 3) + ((size & 0x07) ? 1 : 0 ) ;

        if( map = (unsigned *) calloc( numbytes + sizeof(unsigned) ,1 ) )
                *map = size;

        return (BITMAP *) map;
}

/* ----------------------------------------------------------------- */

setbit( c, map, val )
unsigned  c, val;
char      *map;
{
        /*   Set bit c in the map to val.                            */
        /*   If c > map size, 0 is returned, else 1 is returned.     */
```

(continued on next page)

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Listing Two (Listing continued, text begins on page 18.)

```

        if(  c >= *(unsigned *)map )               /* if c >= map size */
                return 0;

        map += sizeof(unsigned);                   /* Skip past size   */

        if( val ) map[c >> 3]  |=    1 << (c & 0x07)  ;
        else      map[c >> 3]  &=  ~(1 << (c & 0x07)) ;

        return( 1 );
}

/* ------------------------------------------------------------------ */

testbit( c, map )
unsigned c;
char     *map;
{
        /*   Return 1 if the bit corresponding to c in map is set.      */
        /*   0 if it is not.                                             */

        if( c >= *(unsigned *)map )
                return 0;

        map += sizeof(unsigned);

        return(  map[ c >> 3 ]  &  (1 << (c & 0x07)) );
}
```

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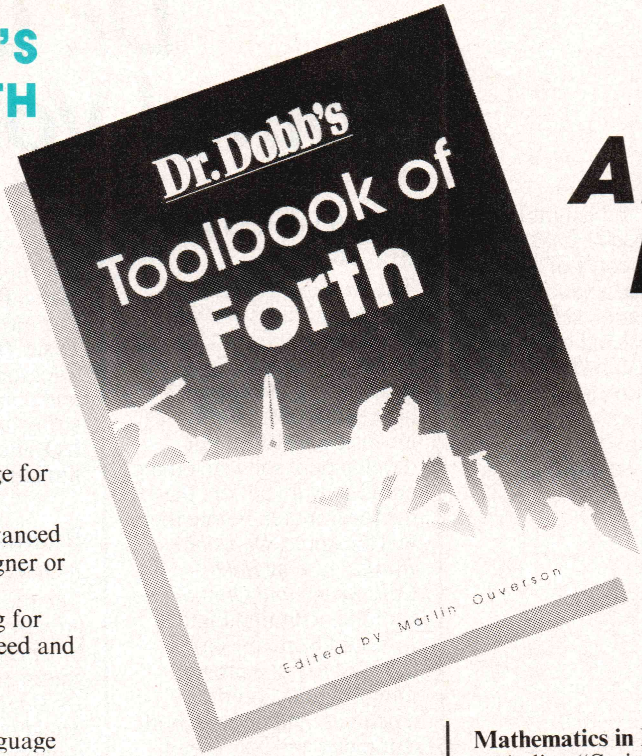

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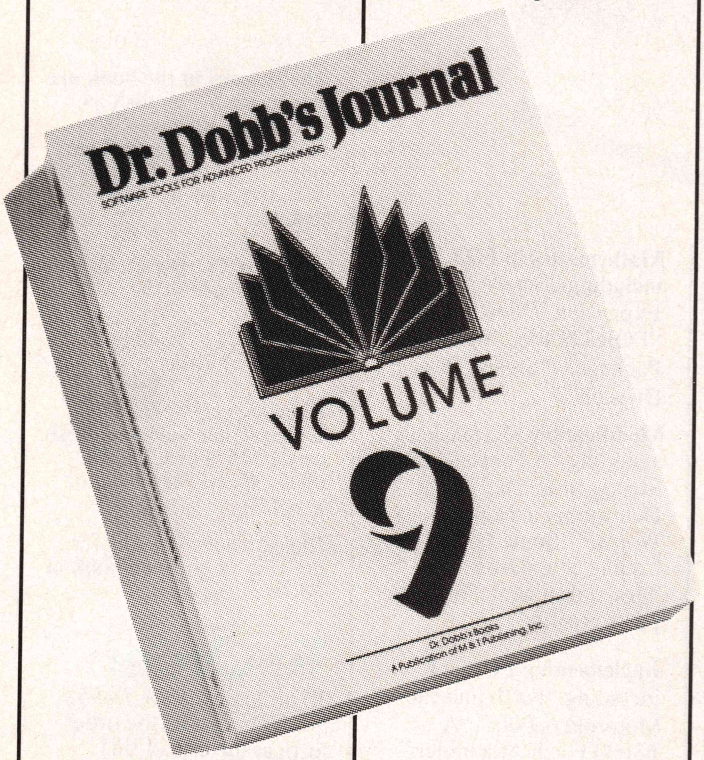

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Running light without overbyte. By year two, *Dr. Dobb's* formula was concocted: tough questions and serious technical issues handled with enthusiasm, wit, and scant reverence for the accepted answers. Source code. Tools for programmers. Respect for tight programming. *Dr. Dobb's Journal* readers shared insights on warping the Intel 8080 into a computer CPU, and *Dr. Dobb's* published a complete operating system for the chip. A motley crop of computers and software products were popping up, and *Dr. Dobb's* investigated: the Heath H-8, the KIM-1, the Alpha Micro, MITS Basic, Poly Basic, and Lawrence Livermore Labs Basic. *Dr. Dobb's* introduced Pilot for microcomputers and published tips on doing string handling, high-speed I/O, and turtle graphics in limited memory.

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The preeminence of CP/M and the rise of C. More than any other magazine, *Dr. Dobb's Journal* was responsible for the spread of CP/M and C on microcomputers. Both of those movements began in 1980. *Dr. Dobb's* all-CP/M issue, including Gary Kildall's history of CP/M, sold out within weeks of publication. This was the year of Ron Cain's original Small C compiler, of a CP/M-oriented C interpreter, CP/M-to-UCSD Pascal file conversion techniques, and of a greater concern in *Dr. Dobb's* with software portability.

Bound Volume 6: 1981
Item #018

The first of Forth. 1981 saw *Dr. Dobb's* first all-Forth issue (now sold out), along with an emphasis on CP/M, C, telecommunications, and new languages. David Cortesi began "Dr. Dobb's Clinic," one of the magazine's most popular features. Highlights included information on PCNET, the Conference Tree, the Electronic Phone Book, Tiny Basic for the 6809, writing your own compiler, and a systems programming language.

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Legitimacy. By 1982 IBM had become a player in the personal computer game and was changing the rules. New microprocessors arrived, the first designed specifically to serve as personal computer CPUs. In *Dr. Dobb's Journal* Dave Cortesi published the first serious comparison of MS DOS and CP/M-86. *Dr. Dobb's* started two new columns: the CP/M Exchange, as a rearguard maneuver to ensure that good tools for CP/M programmers would continue to be developed and circulated, and the 16-Bit Software Toolbox to investigate the 8088/86 and other new microprocessors. We published code for the 68000 and Z8000 processors, and looked ahead, in a provocative essay, to fifth-generation computers.

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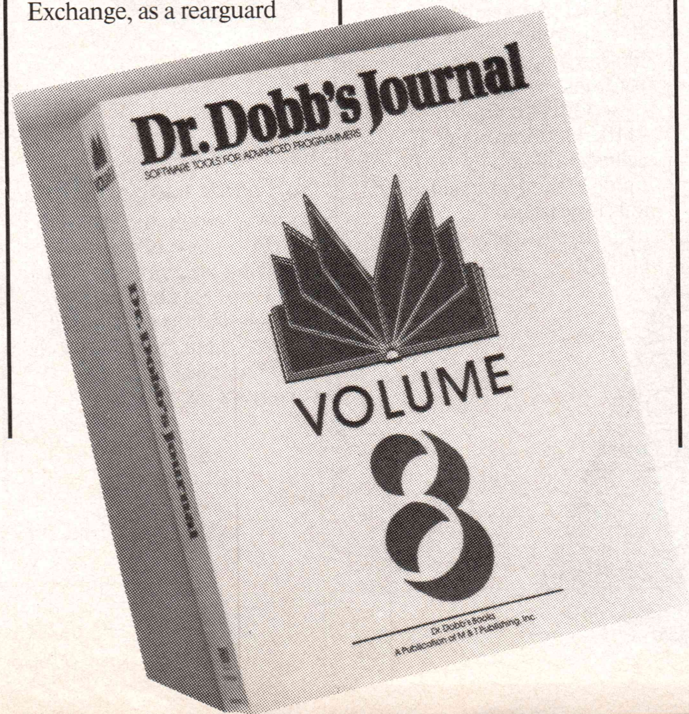
Power tools. Personal computers were proving themselves to be true professional software development tools by 1983, the year in which Jim Hendrix completed his "canonical" version of Small C in *Dr. Dobb's Journal*. *Dr. Dobb's* published more 68000 and 8088 code, and as the memory limitations relaxed, the magazine's commitment to tight code let it shoehorn impossibly large systems into memory. Small C was just one of the major software products published in their entirety in *Dr. Dobb's* pages that year; there were Ed Ream's RED screen editor and a version of the Ada language called Augusta.



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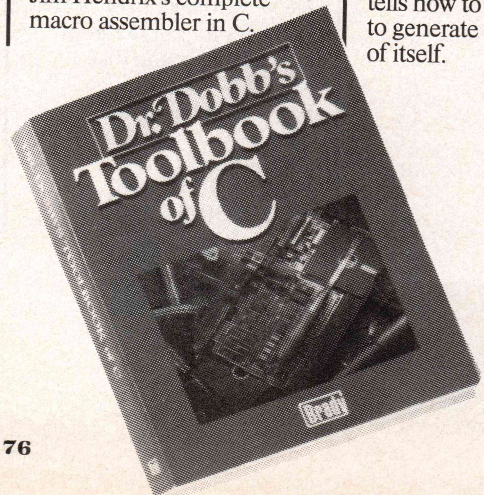

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While both the **Handbook** and the **Toolbook** provide documentation for the Small-C compiler, the **Handbook** contains a more detailed discussion and is available with an addendum for the MS/PC DOS version. The **MS/PC DOS Small-C Handbook Addendum** is recommended in addition to the **Handbook** for MS DOS or PC DOS users.

The **Small-C Compiler** is available for $19.95 in either the CP/M or the MS/PC DOS version.

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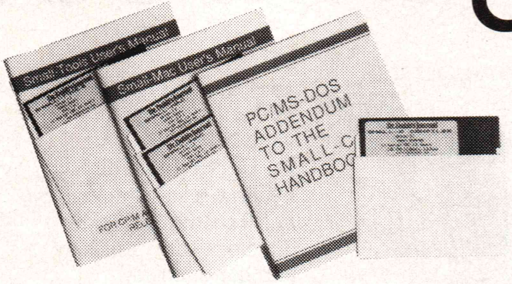

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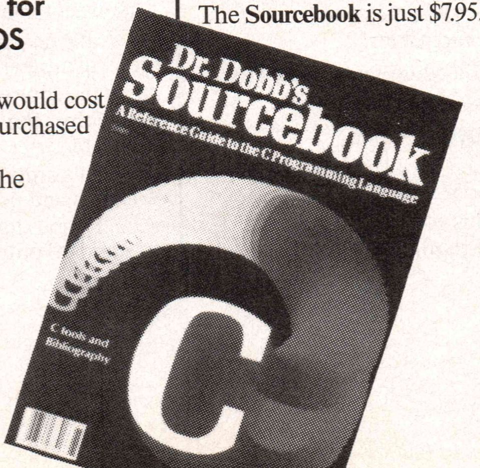

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Ls Gets a sorted directory
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mv Renames a file or directory. Moves files to another directory.
p Prints a file, one page at a time
pause Prints a message and waits for a response
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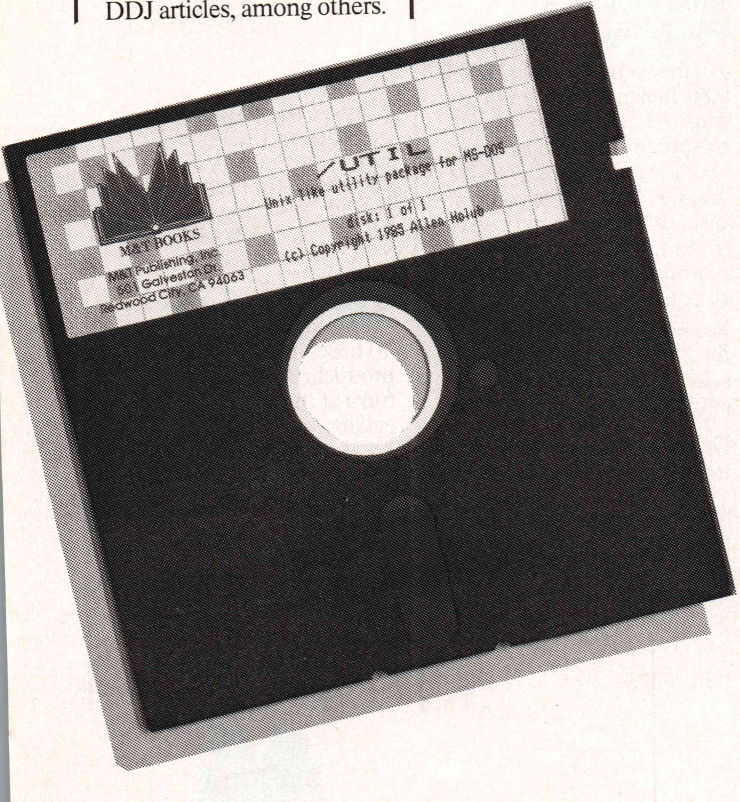

From Issue #111 January 1986

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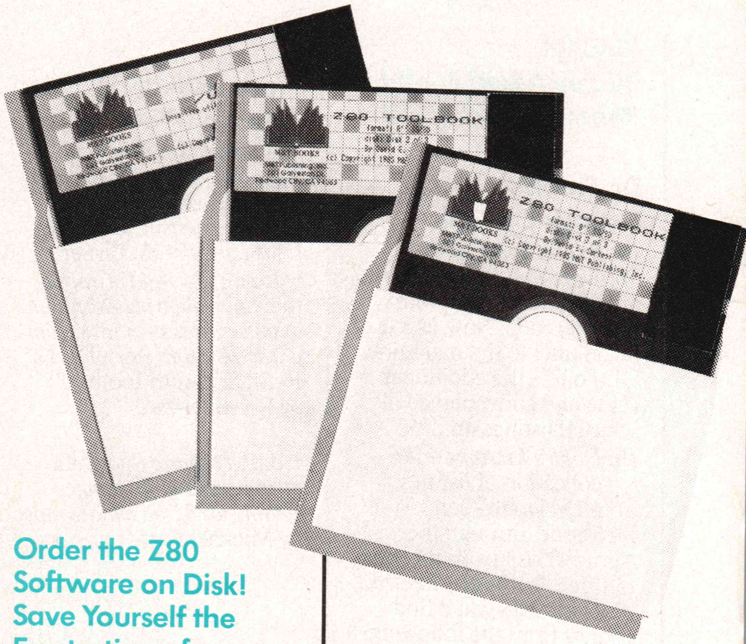

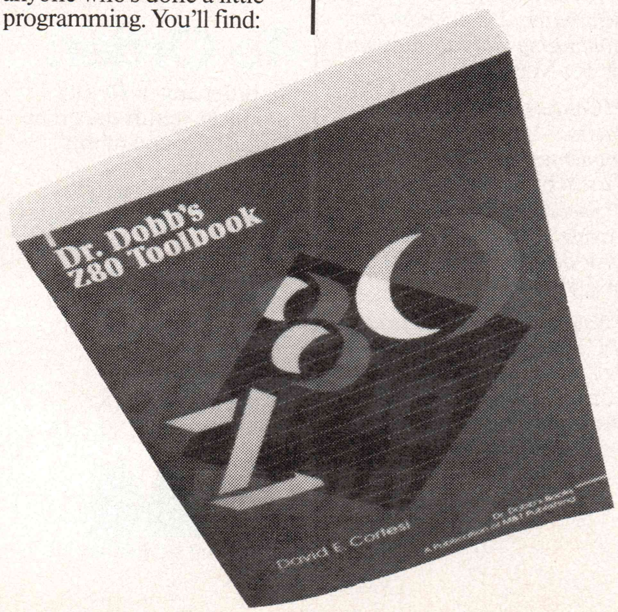

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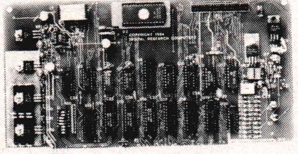

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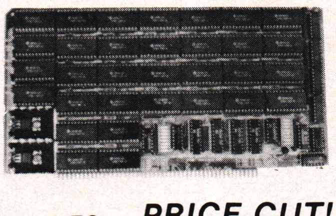

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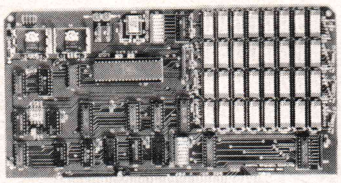

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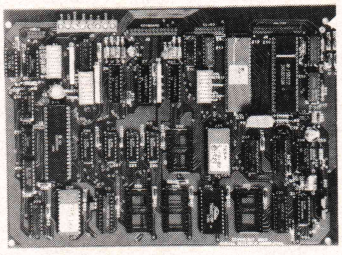

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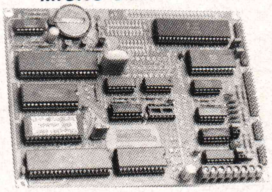

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Listing One (Text begins on page 30.)

```
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Screen   12*
\ FORTH-83 Standard type control structures            GWS 86Mar31
\ note: !0 is 0 SWAP !    ADDR, is ,    (S is (
: >MARK   HERE 2 ALLOT   ;          (S - a )( mark forward branch )
: >RESOLVE   HERE SWAP !   ;      (S a - )( patch forward branch )
: <MARK   HERE   ;          (S - a )( destination for back branch )
: <RESOLVE   ADDR,   ;          (S a - )( compile reference to a )
VARIABLE LEAVE-LIST
: >MARKLIST        (S a - )( extend list at a, link in dictionary )
   HERE SWAP DUP @ ADDR, ( link) ! ( new head) ;
: >RESOLVESLIST          (S a - )( resolve all nodes in a to here )
   DUP @ BEGIN   DUP WHILE   DUP @ SWAP >RESOLVE   REPEAT
   DROP !0   ;    1 2 +THRU

Screen   13
\   conditional compilers - if/else/then begin/while GWS 86Mar31
: IF              (S - a / f - )( compile to branch if f is false )
   COMPILE ?BRANCH   >MARK   ; IMMEDIATE
: ELSE             (S a1 - a2 / - )( compile alternate to IF clause )
   COMPILE BRANCH   >MARK   SWAP >RESOLVE   ; IMMEDIATE
: THEN             (S a - / - )( resolve latest forward reference )
   >RESOLVE   ; IMMEDIATE
: BEGIN   <MARK   ; IMMEDIATE    (S - a / - )( mark loop start )
: WHILE   [COMPILE] IF   ; IMMEDIATE (S - a / f - )( loop exit )
: REPEAT          (S a1 a2 - / - )( branch to beginning of loop )
   COMPILE BRANCH   SWAP <RESOLVE   >RESOLVE   ; IMMEDIATE
: UNTIL (S a - / f - )( branch to beginning of loop until true )
   COMPILE ?BRANCH   <RESOLVE   ; IMMEDIATE

Screen   14
\   do loops                                              GWS 86Mar31
: LEAVE                    (S - / - )( compile exit from structure )
   COMPILE (LEAVE)   LEAVE-LIST >MARKLIST   ; IMMEDIATE
: DO                   (S - n a / n1 n2 - )( initiate counted loop )
   COMPILE (DO)   LEAVE-LIST @   LEAVE-LIST !0   <MARK   ;
   IMMEDIATE
: LOOP                 (S n a - / - )( compile increment loop end )
   COMPILE (LOOP)   <RESOLVE   LEAVE-LIST >RESOLVESLIST
   LEAVE-LIST !   ; IMMEDIATE
: +LOOP           (S n a - / u - )( compile u incremented loop end )
   COMPILE (+LOOP)   <RESOLVE   LEAVE-LIST >RESOLVESLIST
   LEAVE-LIST !   ; IMMEDIATE
```

End Listing One

Listing Two

```
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Screen   15*
\   typical BEGIN loop extensions                         GWS 86Mar31
: RESOLVES      (S 0..a - )( resolve forward branches a until 0 )
   BEGIN   ?DUP WHILE   >RESOLVE   REPEAT   ;
: BEGIN   0 <MARK   ; IMMEDIATE     (S 0 a - )( mark loop start )
: WHILE            (S a1 - a2 a1 / f - )( conditional loop exit )
   [COMPILE] IF   SWAP   ; IMMEDIATE
: REPEAT           (S 0..an a - / - )( terminate repeating loop )
   COMPILE BRANCH <RESOLVE   RESOLVES   ; IMMEDIATE
: UNTIL          (S 0..an a - / f - )( terminate conditional loop )
   COMPILE ?BRANCH <RESOLVE   RESOLVES   ; IMMEDIATE
```

End Listing Two

Listing Three

```
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Screen   3*
\ Proposed Standard Control Structures                 GWS 86Mar31
\ note: !0 is 0 SWAP !    ADDR, is ,    (S is (
: >MARK   HERE 2 ALLOT   ;          (S - a )( mark forward branch )
: >RESOLVE   HERE SWAP !   ;      (S a - )( patch forward branch )
: <MARK   HERE   ;          (S - a )( destination for back branch )
: <RESOLVE   ADDR,   ;          (S a - )( compile reference to a )
: >MARKLIST        (S a - )( extend list at a, link in dictionary )
   HERE SWAP DUP @ ADDR, ( link) ! ( new head) ;
: >RESOLVELIST          (S a - )( resolve top node in a to here )
   DUP @ DUP @ ROT ! ( unlink top node) >RESOLVE   ;
: >RESOLVESLIST          (S a - )( resolve all nodes in a to here )
   DUP @ BEGIN   DUP WHILE   DUP @ SWAP >RESOLVE   REPEAT
   DROP !0   ;    1 6 +THRU

Screen   4
\   compilation list initialization                    GWS 86Mar31
ORPHAN                                       ( make headless words )
VARIABLE IF-LIST   VARIABLE LEAVES-LIST   VARIABLE LEAVE-LIST
VARIABLE LEAVE-CF
: INIT-LISTS                    (S - )( reset all list pointers )
   IF-LIST !0   LEAVE-LIST !0   LEAVES-LIST !0   ;
: SAVE-LISTS          (S - x x x x )( save current list pointers )
   LEAVE-CF @   IF-LIST @   LEAVE-LIST @   LEAVES-LIST @
   INIT-LISTS   ;
: RESTORE-LISTS  (S - x x x x )( restore current list pointers )
   ( could check here for unresolved structures)
   LEAVES-LIST !   LEAVE-LIST !   IF-LIST !   LEAVE-CF !   ;
ADOPT                                          ( make headed words )

Screen   5
\ Conditional compilers - if/else/then & case          GWS 86Mar31
: IF                  (S - / f - )( compile to branch if f is false )
   COMPILE ?BRANCH   IF-LIST >MARKLIST   ; IMMEDIATE
: ELSE                (S - / - )( compile alternate to IF clause )
   COMPILE BRANCH   IF-LIST >MARKLIST   IF-LIST @ ( if branch)
   >RESOLVELIST   ; IMMEDIATE
: THEN                (S - / - )( resolve latest forward reference )
   IF-LIST >RESOLVELIST   ; IMMEDIATE
: CASE            (S - x x x x / ? - ? )( setup for case statement )
   SAVE-LISTS   ['] BRANCH LEAVE-CF !   ; IMMEDIATE
: ENDCASE     (S - / x x x x - )( restore lists, resolve leaves )
   LEAVES-LIST >RESOLVESLIST   RESTORE-LISTS   ; IMMEDIATE

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Screen   6*
\   common loop end and exit                           GWS 86Mar31
ORPHAN                                       ( make headless words )
: LOOPEND        (S x x x x a1 a2 - )( resolve list a2 & branch )
( a1, restore values x, transfer leaves-list to if-list )
   SWAP <RESOLVE ( back branch) >RESOLVESLIST ( forward branch)
   LEAVES-LIST @ ?DUP IF   >R   RESTORE-LISTS   IF-LIST @   R@
   BEGIN   DUP @ WHILE   @   REPEAT ( find leaves list end) !
   ( link to if list) R> IF-LIST !   ELSE   RESTORE-LISTS
   THEN   ;
ADOPT                                          ( make headed words )
: OUTSIDE   (S - / - )( allow LEAVES outside current loop level)
   IF-LIST @ DUP @ IF-LIST ! ( unlink) LEAVES-LIST @ OVER !
   COMPILE-UNNEST   LEAVES-LIST ! ( relink) ; IMMEDIATE

Screen   7
\   do loops                                              GWS 86Mar31
: LEAVE                    (S - / - )( compile exit from structure )
   LEAVE-CF @ ADDR,   LEAVE-LIST >MARKLIST   ; IMMEDIATE
: LEAVES              (S - / - )( compile exit to outside structure )
   LEAVE-CF @ ADDR,   LEAVES-LIST >MARKLIST   [COMPILE] THEN ;
   IMMEDIATE
: DO            (S - x x x x a / u u - )( initiate counted loop )
   SAVE-LISTS   ['] (LEAVE) LEAVE-CF !   COMPILE (DO)
   <MARK   ; IMMEDIATE
: LOOP            (S x x x x a - / - )( compile increment loop end )
   COMPILE (LOOP)   LEAVE-LIST LOOPEND   ; IMMEDIATE
: +LOOP               (S x x x x a - / u - )( compile u+ loop end )
   COMPILE (+LOOP)   LEAVE-LIST LOOPEND   ; IMMEDIATE

Screen   8
\   more loops                                            GWS 86Mar31
: BEGIN              (S - x x x x a / - )( mark start of a loop )
   [COMPILE] CASE   <MARK   ; IMMEDIATE
: REPEAT          (S x x x x a - / - )( terminate repeating loop )
   COMPILE BRANCH   IF-LIST LOOPEND
   LEAVE-LIST >RESOLVESLIST   ; IMMEDIATE
: UNTIL           (S x x x x a - / - )( terminate repeating loop )
   COMPILE ?BRANCH   IF-LIST LOOPEND
   LEAVE-LIST >RESOLVESLIST   ; IMMEDIATE
: WHILE   [COMPILE] IF   ; IMMEDIATE   (S - )( for compatibility)
```

End Listing Three

Listing Four

```
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Screen    9*
\   suggested extensions                                GWS 86Mar31

: ?LEAVE                    (S - / f - )( leave do loop if tf )
  COMPILE (?LEAVE)    LEAVE-LIST >MARKLIST    ; IMMEDIATE
: ?LEAVES                   (S - / f - )( leave do loop if tf )
  COMPILE (?LEAVE)    LEAVES-LIST >MARKLIST    ; IMMEDIATE

: THENS                (S - / - )(  resolve all outstanding IFs )
  IF-LIST >RESOLVESLIST    ; IMMEDIATE
: ELSES   (S - / - )( resolve all outstanding IFs w/common ELSE )
  [COMPILE] ELSE    IF-LIST @ >RESOLVESLIST    ; IMMEDIATE
```

End Listing Four

Listing Five

```
Previously Proposed Solutions               Proposed Solution

BEGIN ...                                   same
   WHILE ...
   WHILE ...
   ...
REPEAT

BEGIN ...                                   same
   WHILE ...
   WHILE ...
   ...
UNTIL

BEGIN ...                                   BEGIN ...
   WHILE ...                                   WHILE
   ANDWHILE ...                                WHILE
   ANDWHILE ...                                WHILE
   ...                                         ...
REPEAT                                      REPEAT

BEGIN ...                                   BEGIN ...
   WHILE   aa                                  NOT IF    ff    LEAVES   aa
   WHILE   bb                                  NOT IF    ee    LEAVES   bb
   WHILE   cc                                  WHILE   cc
   ...                                         ...
REPEAT   dd                                 REPEAT   dd
   <WHILE   ee
   <WHILE   ff
<END                                        THEN   THEN

BEGIN ...                                   see below
   IF ... LEAVE THEN
   IF ... LEAVE THEN
   ...
REPEAT

BEGIN ...                                   BEGIN ...
   UNLESS ... FINISH                           IF ... LEAVES
   UNLESS ... FINISH                           IF ... LEAVES
   ...
AGAIN                                       REPEAT THEN THEN

DO ...                                      DO ...
   PERHAPS ... ESCAPE                          IF ... LEAVES
   PERHAPS ... ESCAPE                          IF ... LEAVES
   ...                                         ...
LOOP ...                                    LOOP ...
ESCAPED ...                                 THEN THEN ... (or ELSE ...
                                                                  THEN)

DO ...                                      DO ...
   IF ... LEAVE THEN    aa                     IF ... LEAVES     aa
LOOP--FALLTHRU:    bb                       LOOP   bb
THEN    cc                                  THEN   cc

DO ...                                      DO ...
   WHEN ...                                    NOT IF    LEAVE THEN ...
LOOP                                        LOOP

DO ...                                      DO ...
   NOTWHEN ...                                 IF    LEAVE THEN ...
LOOP                                        LOOP

DO ...                                      DO ...
   IF   LEAVE THEN ...                         IF    LEAVES
EXITING LOOP                                LOOP
...                                         ...
THEN                                        THEN

none                                        DO ...
                                               DO ...
                                                  IF    LEAVES
                                                  ...
                                               LOOP OUTSIDE
                                            LOOP
                                            ...
                                            THEN

none                                        BEGIN ...
                                               BEGIN ...
                                                  IF   LEAVES
                                                  ...
                                               REPEAT OUTSIDE
                                            REPEAT
                                            ...
                                            THEN

<STEPS ...                                  CASE
   &IF ...                                     IF ...
   &IF ...                                     IF ...
STEPS>                                         THENS
                                            ENDCASE

IF ... ELSE ...                             IF ... ELSE ...
THENIF ... ELSE                             IF ... ELSE ...
THENIF ... ELSE                             IF ... ELSE ...
...                                         ...
THEN                                        THENS   or

                                            CASE
                                               IF ... LEAVES
                                               IF ... LEAVES
                                               ...
                                            ENDCASE

IF ...                                      IF ...
   ANDIF ...                                   IF ...
      ANDIF ...                                   IF ...
      ...                                         ...
( ELSE)                                     ( ELSES)
THEN                                        THENS ( THEN)

CASE ...                                    CASE ...
   OF ... ENDOF                                OVER = IF ... LEAVES
   OF ... ENDOF                                OVER = IF ... LEAVES
   ...                                         ...
ENDCASE                                     DROP ENDCASE
```

End Listings

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Circle **no. 177** on reader service card.

Listing One (Text begins on page 40.)

```
****************************************************************
*     RAFOS FORTH V1.0        26 March 1986                     *
*     -- ROM #1 of 2                                             *
*                                                                *
*   (C) Copyright 1986, Everett Carter. All rights reserved.    *
*                                                                *
*   This FORTH is a subset of the FORTH-79 standard.            *
*   Some changes have been made in order to save on             *
*   space in the limited memory of the float.                   *
*                                                                *
****************************************************************
*
*     EQUATES FOR ROM 2
QUES     EQU    $1000
*
TOG6     EQU    $105F            TOGGLE
IMM9     EQU    $1089            IMMEDIATE
DFND     EQU    $109B            -FIND
COU5     EQU    $10B1            COUNT
ZERO     EQU    $10C3            0
ONE      EQU    $10D8            1
TWO      EQU    $10EF            2
TWOP     EQU    $1106            2+
LBRAK    EQU    $1121            [
RBRAK    EQU    $1131            ]
DEFS     EQU    $1143            DEFINITIONS
PLUS     EQU    $1155            +
MINUS    EQU    $117C            -
UMULT    EQU    $11A7            U*
*
PAD      EQU    $1289            PAD
LSHP     EQU    $129B            <#
OVER     EQU    $12AB            OVER
SPGR     EQU    $12CE            #>
TOR      EQU    $12E6            >R
RTO      EQU    $130A            R>
RFTCH    EQU    $132E            R@
ROT      EQU    $134F            ROT
HOLD     EQU    $1361            HOLD
*
COMP     EQU    $1557            COMPILE
SEMI     EQU    $156D            ;
COLON    EQU    $157F            :
TICK     EQU    $159B            '
VAR8     EQU    $15C5            VARIABLE
*
I1       EQU    $17EE            I
*
LATEST EQU I1-6                  Last Dictionary entry
*
ROM      EQU    $1800            ROM #1 start address
*
CR       EQU    $0D              CARRIAGE RETURN
LF       EQU    $0A              LINE FEED
BL       EQU    $20              BLANK
BS       EQU    $08              Back Space
DEL      EQU    $7F              Delete
*
DDR      EQU    4                DATA DIRECTION REGISTER OFFSET
*
PORTA    EQU    0                I/O PORT 0
PORTB    EQU    1                I/O PORT 1
PUT      EQU    PORTB            SERIAL I/O PORT
*
INITSP   EQU    $7F              INITIAL STACK POINTER VALUE
STACK    EQU    INITSP-5         TOP OF STACK
MEMSIZ   EQU    $2000            MEMORY ADDRESS SPACE SIZE
*
SP0      EQU    $0F00
RP0      EQU    $0E00
TIB      EQU    $0D80
*
*
*
*    RAM VARIABLES
*
*        ORG    $10              ON-CHIP RAM (112 BYTES)
*
ATEMP    EQU    $10              TEMP USED IN PUTDEC
XTEMP    EQU    $11              INDEX TEMPORARY
GETR     EQU    $12              PICK & DROP TEMPORARY
COUNT    EQU    $16              NUMBER OF BITS LEFT TO get/send
CHAR     EQU    $17              Current input/output character
*
BYTCNT   EQU    $1E              bytcnt.
WTIME    EQU    $20              TIMER INTERRUPT FROM WAIT STATE
*
*
PH       EQU $21             MISC SCRATCH AREAS
PL       EQU $22
TEMPA    EQU $23
TEMPB    EQU $24
QH       EQU $25
QL       EQU $26
TEMP     EQU $27
TERM     EQU $28
*
         ORG $0029
*
IN       FCB #0              Where FORTH will look for input
OUT      FCB #0
COUNTR   FCB #0
DP       FDB #$01D0          The initial Dictionary pointer
START    FDB #0              The start up vector
*
*
IP       FDB #0              THE FORTH INSTRUCTION POINTER
RP       FCB #0              THE RETURN POINTER OFFSET
SP       FCB #0              THE STACK POINTER OFFSET
BASE     FCB #$10
*
USER     EQU *               The space for USER variables
FENCE    EQU 0               USER + 0
         FDB #0                       INITIALIZE USER VARS
STATE    EQU 2               USER + 2
         FDB #0
FORTH    EQU 4               USER + 4
         FDB #0
CONTEXT  EQU 6               USER + 6
         FDB USER+FORTH
CURRENT  EQU 8               USER + 8
         FDB USER+FORTH
HLD      EQU $0A             USER + $0A
         FDB #0
*
      ORG $0080
*
*        The start of the INNER interpreter
*
DOCOL  LDX RP                          * Push IP to RS
*
DOCOL1 EQU DOCOL
*
       DECX
       LDA IP+1
       STA RP0,X
       DECX
       LDA IP
       STA RP0,X
       STX RP
       LDA NEXT1+2
       ADD #2
       STA IP+1
       LDA NEXT1+1
       ADC #0
       STA IP
*
*      fall thru to NEXT
*
NEXT   LDA IP+1                NEXT The Inner Interpreter
       STA CA+2                SELF-MODIFYING
       LDA IP
       STA CA+1
CA     LDA SP0               -- SP0 is a dummy
       STA NEXT1+1
       LDA IP+1
       ADD #1
       STA CA2+2
       LDA IP
       ADC #0
       STA CA2+1
CA2    LDA SP0                 -- SP0 is a dummy
       STA NEXT1+2
       LDA IP+1
       ADD #2
       STA IP+1
       LDA IP
       ADC #0
       STA IP
NEXT1  JMP COLD                -- COLD is a dummy
*
*       SELF MODIFYING CODE FIRST
*
LOAD     STA SP0,X                      STA (HERE),X
         RTS                            move A to HERE+X
*
GET      LDA SP0,X                      LDA (HERE),X
         RTS                            get HERE+X into A
*
       FCB 4                  TYPE  -- SELF MODIFYING
       FCC 'TYP'
       FDB #0                 end link
TYPE   LDX SP
       INCX                   Drop high byte
       LDA SP0,X
       INCX
       STA COUNTR             COUNTR = byte count
       LDA SP0,X
       INCX
       STA TYSCR+1
       LDA SP0,X
       INCX
       STA TYSCR+2
       STX SP
       CLR OUT
```

```
        TST COUNTR
        BEQ TXIT
TLOOP   LDX OUT
TYSCR   LDA SP0,X            -- SP0 is a dummy
        JSR OUTCHAR
        INC OUT
        LDA OUT
        SUB COUNTR
        BMI TLOOP
TXIT    JMP NEXT
*
*
        FCB 6                <FIND> -- SELF MODIFYING
        FCC '<FI'
        FDB TYPE-6           link to TYPE
FIN6    LDX SP
        LDA SP0,X            get addr1 high
        INCX
        STA GET+1
        LDA SP0,X            addr1 low
        INCX
        STA GET+2
        LDA SP0,X            get addr2 high
        INCX
        STA FINSCR+1
        STA FINCNT+1
        LDA SP0,X
        INCX
        STA FINSCR+2
        STA FINCNT+2
        STX SP
FINCNT  LDA SP0              -- SP0 is a dummy
        STA COUNTR           save byte count
        TSTA                 count = 0 ?
        BEQ NONE
FINLP1  CLRX
FINLP2  JSR GET
        AND #$7F             ignore bit 7
FINSCR  CMP SP0,X            -- SP0 is a dummy
        BNE NFND
        CPX #3               X = 3 ? if so quit as FOUND
        BEQ FOUND
        CPX COUNTR           X = count ?
        BEQ FOUND
        INCX
        BRA FINLP2
NFND    LDX #4               Not found, go to next element
        JSR GET
        STA ATEMP
        INCX
        JSR GET
        ORA ATEMP            =0 ?
        BEQ NONE             if yes, end of list
        JSR GET              else move new pointer to get
        STA GET+2
        LDA ATEMP
        STA GET+1
        BRA FINLP1           and try again
NONE    LDX SP               nothing, push a FALSE to stack
        CLRA
        BRA FQUIT
FOUND   LDX SP
        LDA GET+2            push CA of found word
        ADD #6
        DECX
        STA SP0,X
        LDA GET+1
        ADC #0
        DECX
        STA SP0,X
        STX SP
        CLRX
        JSR GET              get the byte count and push it
        LDX SP
        DECX
        STA SP0,X
        CLRA
        DECX
        STA SP0,X
        LDA #$FF             push a TRUE flag
FQUIT   DECX
        STA SP0,X
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 4                BRAN -- SELF MODIFYING
        FCC 'BRA'
        FDB  FIN6-6          link to <FIND>
BRAN    LDA IP
        STA BRSC1+1
        STA BRSC2+1
        LDA IP+1
        STA BRSC1+2
        STA BRSC2+2
        LDX #1
BRSC1   LDA SP0,X
        ADD IP+1
        STA IP+1
        CLRX
BRSC2   LDA SP0,X
        ADC IP
```

(continued on next page)

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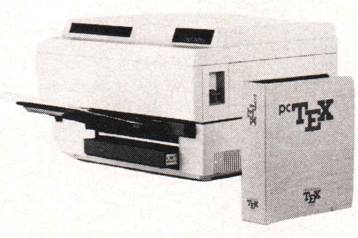

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Circle **no. 76** on reader service card.

Listing One (Listing continued, text begins on page 40.)

```
        STA IP
        JMP NEXT
*****************************************************************
*
*      NO SELF MODIFYING CODE BEYOND THIS POINT
*
OFFSET EQU *
        ORG ROM+OFFSET          *  ROM #2 ORIGIN
*
*
        FCB 7                  0BRANCH
        FCC '0BR'
        FDB BRAN-6             link to BRAN
ZBRAN   LDX SP
        LDA SP0,X
        INCX
        ORA SP0,X
        INCX
        STX SP
        TSTA
        BNE ZBREX
        JMP BRAN
ZBREX   LDA IP+1               bump IP past offset
        ADD #2
        STA IP+1
        LDA IP
        ADC #0
        STA IP
        JMP NEXT
*
        FCB 4                     EXIT
        FCC 'EXI'
        FDB ZBRAN-6                link to 0BRANCH
EXIT    LDX RP                    Pop RS into IP
        LDA RP0,X                 High byte
        INCX
        STA IP
        LDA RP0,X                 then low byte
        INCX
        STA IP+1
        STX RP
        JMP NEXT
*
        FCB 7                     EXECUTE
        FCC 'EXE'
        FDB EXIT-6                link to EXIT
EXE7    LDX SP                    Pop SP into W (NEXT1+1)
        LDA SP0,X                 First high byte
        INCX
        STA NEXT1+1
        LDA SP0,X              Then low byte
        INCX
        STA NEXT1+2
        STX SP
        JMP NEXT1
*
INLINE JSR CRLF
        LDA #BL
        CLR COUNTR
        CLRX                    Clear line buffer
INLP1   STA TIB,X
        INCX
        CPX #$7E                Buffer end ?
        BNE INLP1
        CLR IN
        CLRX                    Clear buffer pointer
INLP2   JSR GETCHAR              ( X = IN )
        CMP #DEL                = DELETE ?
        BNE INTST2              branch if not
INDEL   CPX #0
        BEQ INLP2               Skip if IN (LBP) = 0 already
        DECX
        LDA #BL                 DELETE CHAR
        STA TIB,X
        LDA #BS
        JSR OUTCHAR
        LDA #BL
        JSR OUTCHAR
        LDA #BS
        JSR OUTCHAR
        BRA INLP2
INTST2 CMP #BS                 maybe its a backspace
        BEQ INDEL
        CMP #CR                 or a CR
        BEQ INEX
        STA TIB,X
        CPX #$7D
        BHS INSKP
        INCX
INSKP   JSR OUTCHAR
        BRA INLP2               Back to main loop
INEX    LDA #BL
        JSR OUTCHAR
        JMP NEXT
*
        FCB 4                     EMIT
        FCC 'EMI'
        FDB EXE7-6                link to EXECUTE
EMIT    LDX SP
        INCX                      drop high byte
        LDA SP0,X
        INCX
        STX SP
        JSR OUTCHAR
        JMP NEXT
*
        FCB 2                    BL
        FCC 'BL '
        FDB EMIT-6               link to EMIT
BL2     LDX SP
        LDA #BL
        DECX
        STA SP0,X
        CLRA
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 4                    WORD
        FCC 'WOR'
        FDB BL2-6                link to BL
WORD    LDA DP                   start by setting up LOAD
        STA LOAD+1
        LDA DP+1
        STA LOAD+2
        CLR COUNTR
        CLRA
        CLRX
        JSR LOAD               clear DP
        LDX SP                 get terminator
        INCX                   drop high byte
        LDA SP0,X
        STA TERM
        INCX
        STX SP
        LDX IN                 get INput pointer
        CMP #BL                seperator = space ?
        BNE TOK
IGNBL   LDA TIB,X              ignore blank
        CMP #BL
        BNE TOK
        INCX
        BRA IGNBL
TOK     INC COUNTR
        LDA TIB,X
        STX XTEMP               save X
        LDX COUNTR
        JSR LOAD               move char to DP + COUNTR
        LDX XTEMP               get X back
        INCX
        CMP #$80               character = buffer end ?
        BEQ WORXIT
        CMP TERM
        BNE TOK                continue unless terminator
WORXIT STX IN                  save new value of IN
        LDA COUNTR             move count-1 to DP
        DECA
        CLRX
        JSR LOAD
        LDA DP+1               Push DP addr to stack
        LDX SP
        DECX
        STA SP0,X
        LDA DP
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
MPY16   LDX #$10               16 bit X 16 bit multiply   32 bit result
        CLR TEMPA
        CLR TEMPB
        ROR QH
        ROR QL
MPYNXT BCC ROTAT
        LDA TEMPB
        ADD PL
        STA TEMPB
        LDA TEMPA
        ADC PH
        STA TEMPA
ROTAT   ROR TEMPA
        ROR TEMPB
        ROR QH
        ROR QL
        DECX
        BNE MPYNXT
        RTS
*
```

```
        FCB 8                 <NUMBER>
        FCC '<NU'
        FDB WORD-6            link to WORD
NUM8    LDX SP                pop stack into GET
        LDA SP0,X
        INCX
        STA GET+1
        LDA SP0,X
        INCX
        STA GET+2
        STX SP
        CLRX                  Put char count into COUNTR
        JSR GET
        STA COUNTR
        TSTA                  count = 0 ?
        BEQ NOTNO
        INCX
        CLR TEMP              TEMP is the sign flag
        CLR QH
        CLR QL
        CLR PH                Set P = BASE
        LDA BASE
        STA PL
        JSR GET               Get first char
        CMP #$2D              = '-' ?
        BNE NUMSKP
        DEC TEMP              Minus flag = TRUE
        INCX                  bump X
        CPX COUNTR            X > COUNTR ?
        BHI NOTNO
        JSR GET
NUMSKP  INCX                  at this point X points 1 past char in A
        SUB #$30
        BMI NOTNO             if negative, not a number
        CMP #$0A              less than 10 ?
        BMI NUMB
        CMP #$11              valid char?
        BMI NOTNO
        SUB #7
NUMB    CMP BASE              valid for this base ?
        BLO ANUMB
NOTNO   CLRA                  NOPE, push a FALSE
NUMXT   LDX SP
        DECX
        STA SP0,X
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
ANUMB   STX XTEMP             save X in XTEMP
        STA ATEMP             and A in ATEMP
        JSR MPY16             Q =          Q * BASE
        LDA ATEMP             get A back
        ADD QL                Q = Q + A
        STA QL
        LDA QH
        ADC #0
        STA QH
        LDX XTEMP             get X back
        CPX COUNTR            X > COUNTR ?
        BHI NUMOK
        JSR GET
        BRA NUMSKP
NUMOK   LDA TEMP              number OK, now check sign
        TSTA
        BEQ NUMPOS
        CLRA
        NEG QL
        SBC QH
        STA QH
NUMPOS  LDX SP                push number at Q and flag
        LDA QL
        DECX
        STA SP0,X
        LDA QH
        DECX
        STA SP0,X
        LDA #$FF              TRUE flag
        BRA NUMXT+2
*
        FCB 4                 DROP
        FCC 'DRO'
        FDB NUM8-6            link to <NUMBER>
DROP    LDX SP
        INCX
        INCX
        STX SP
        JMP NEXT
*
        FCB 2                 C@
        FCC 'C@ '
        FDB DROP-6            link to DROP
CFCH    LDX SP
        LDA SP0,X
        INCX
        STA GET+1
        LDA SP0,X
        STA GET+2
        STX SP
        CLRX                  get the byte
        JSR GET
        LDX SP
```

(continued on next page)

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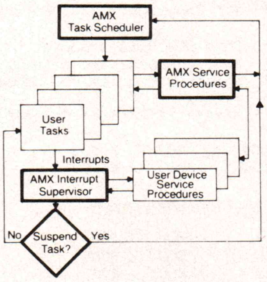

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Circle **no. 210** on reader service card.

Listing One

(Listing continued, text begins on page 40.)

```
        STA SP0,X
        CLRA                    zero high byte
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 1                   @
        FCC '@  '
        FDB CFCH-6              link to C@
FTCH    LDX SP
        LDA SP0,X
        INCX
        STA GET+1
        LDA SP0,X
        STA GET+2
        STX SP
        LDX #1                  get low byte
        JSR GET
        LDX SP
        STA SP0,X
        CLRX                    get high byte
        JSR GET
        LDX SP
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 2                   DP
        FCC 'DP '
        FDB FTCH-6              link to @
DP2     LDX SP                  push address of DP to stack
        LDA #DP                 this routine knows that DP is on
        DECX                                          page zero
        STA SP0,X
        CLRA
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 4                   HERE
        FCC 'HER'
        FDB DP2-6               Link to DP
HERE    JMP DOCOL
        FDB DP2
        FDB FTCH
        FDB EXIT
*
        FCB 3                   NOT
        FCC 'NOT'
```

End Listing One

Listing Two

```
****************************************************************
*      RAFOS FORTH V1.0       26 March  1986                   *
*                                                              *
*   --- ROM #2 of 2                                            *
*                                                              *
*  (C) Copyright 1986, Everett Carter. All rights reserved.    *
*                                                              *
*  This FORTH is a subset of the FORTH-79 standard.            *
*  Some changes have been made in order to save on             *
*  space in the limited memory of the float.                   *
*                                                              *
****************************************************************
*
ROM      EQU     $1000          ROM #2 start address
ROM1     EQU     $1800          ROM #1 start address
*
         ORG     ROM
*
CR       EQU     $0D            CARRIAGE RETURN
LF       EQU     $0A            LINE FEED
BL       EQU     $20            BLANK
BS       EQU     $08            Back Space
DEL      EQU     $7F            Delete
*
DDR      EQU     4              DATA DIRECTION REGISTER OFFSET
*
PORTA    EQU     0              I/O PORT 0
PORTB    EQU     1              I/O PORT 1
PUT      EQU     PORTB          SERIAL I/O PORT
*
INITSP   EQU     $7F            INITIAL STACK POINTER VALUE
STACK    EQU     INITSP-5       TOP OF STACK
MEMSIZ   EQU     $2000          MEMORY ADDRESS SPACE SIZE
*
SP0      EQU     $0F00
RP0      EQU     $0E00
TIB      EQU     $0D80
*
*
*
*       RAM VARIABLES
*
*
ATEMP    EQU     $10            TEMP USED IN PUTDEC
XTEMP    EQU     $11            INDEX TEMPORARY
GETR     EQU     $12            PICK & DROP TEMPORARY
COUNT    EQU     $16            NUMBER OF BITS LEFT TO get/send
CHAR     EQU     $17            Current input/output character
*
BYTCNT   EQU     $1E            bytcnt.
WTIME    EQU     $20            TIMER INTERRUPT FROM WAIT STATE
*
*
PH       EQU $21                MISC SCRATCH AREAS
PL       EQU $22
TEMPA    EQU $23
TEMPB    EQU $24
QH       EQU $25
QL       EQU $26
TEMP     EQU $27
TERM     EQU $28
*
*
IN       EQU $29                   Where FORTH will look for input
OUT      EQU $2A
COUNTR   EQU $2B
DP       EQU $2C                The initial Dictionary pointer
START    EQU $2E                The start up vector
*
*
IP       EQU $30                   THE FORTH INSTRUCTION POINTER
RP       EQU $32                   THE RETURN POINTER OFFSET
SP       EQU $33                   THE STACK POINTER OFFSET
BASE     EQU $34
*
USER     EQU $35                   The space for USER variables
FENCE    EQU 0                     USER + 0
STATE    EQU 2                     USER + 2
FORTH    EQU 4                     USER + 4
CONTEXT  EQU 6                     USER + 6
CURRENT  EQU 8                     USER + 8
HLD      EQU $0A                   USER + $0A
*
*
*  List of previous FORTH words (ROM 1)
*
DOCOL   EQU $80                 DOCOL
DOCOL1  EQU DOCOL
NEXT    EQU $009E               NEXT
NEXT1   EQU $00CE
LOAD    EQU $00D1
GET     EQU $00D5
TYPE    EQU $00DF               TYPE
FIN6    EQU $0116               <FIND>
BRAN    EQU $01A9               BRAN
ZBRAN   EQU $19D2               ZBRANCH
ZBREX   EQU ZBRAN+$12
EXIT    EQU $19F8               EXIT
EXE7    EQU $1A10               EXECUTE
INLINE  EQU $1A22
EMIT    EQU $1A79               EMIT
BL2     EQU $1A8D               BL
WORD    EQU $1AA4               WORD
MPY16   EQU $1AFD
NUM8    EQU $1B27               <NUMBER>
DROP    EQU $1BBE               DROP
CFCH    EQU $1BCC               C@
FTCH    EQU $1BF2               @
DP2     EQU $1C1D               DP
HERE    EQU $1C34               HERE
NOT3    EQU $1C42               NOT
ONEP    EQU $1C5B               1+
HLD3    EQU $1C78               HLD
DOUSE   EQU $1C7A               DOUSE
STA5    EQU $1C91               STATE
CON7    EQU $1C9B               CONTEXT
CUR7    EQU $1CA5               CURRENT
FOR5    EQU $1CAF               FORTH
STO     EQU $1CB9               !
CSTO    EQU $1CE4               C!
COMA    EQU $1D04               ,
CCOMA   EQU $1D37               C,
DUP3    EQU $1D55               DUP
PLSTO   EQU $1D75               +!
LAT6    EQU $1DAE               LATEST
ALL5    EQU $1DBE               ALLOT
LIT3    EQU $1DCC               LIT
SWAP    EQU $1F07               SWAP
CRE6    EQU $1FDE               CREATE
*
*
*
LOK     EQU $1E53
OK      EQU LOK+1
*
```

```
*
OUTER EQU $1E57
*
COLD  EQU $1EA5
WARM  EQU $1EE6
GETC  EQU $1F43
GETCHAR  EQU GETC
PUTC   EQU $1F7A
OUTCHAR  EQU PUTC
WAIT   EQU $1FA8
DELAY  EQU WAIT
CRLF   EQU $1FC3
*
RESET  EQU COLD
*
***********************************************************
*
QUES   LDA DP           checks for errors at end of OUTER
       STA GET+1
       LDA DP+1
       STA GET+2
       LDX #1
       JSR GET
       CMP #$80         = buffer end ?
       BNE QERR
QEXIT  LDX SP
*
H1     EQU LOK/$100*$100
L      EQU LOK-H1
H      EQU LOK/$100
*
       LDA #L
       DECX
       STA SP0,X
       LDA #H
       DECX
       STA SP0,X
       STX SP
       LDA START
       STA IP
       LDA START+1
       STA IP+1
       JMP NEXT
QERR   LDA DP
       STA LOAD+1
       LDA DP+1
       STA LOAD+2
       CLRX
       JSR GET
       INCA
       INCA
       JSR LOAD
       TAX
       LDA #$3F         A='?'
       JSR LOAD
       LDX SP
       LDA DP+1
       DECX
       STA SP0,X
       LDA DP
       DECX
       STA SP0,X
       STX SP
       JMP WARM
*
       FCB 4            QUIT
       FCC 'QUI'
       FDB CRE6-6       link to CREATE
QUIT   BRA QEXIT
*
       FCB 6            TOGGLE
       FCC 'TOG'
       FDB QUIT-6       link to QUIT
TOG6   LDX SP
       INCX             drop high byte
       LDA SP0,X
       INCX
       STA ATEMP
       LDA SP0,X        get addr
       INCX
       STA LOAD+1
       STA GET+1
       LDA SP0,X
       INCX
       STX SP
       STA LOAD+2
       STA GET+2
       CLRX
       JSR GET
       EOR ATEMP
       JSR LOAD
       JMP NEXT
*
       FCB 9            IMMEDIATE
       FCC 'IMM'
       FDB TOG6-6       link to TOGGLE
IMM9   JMP DOCOL
       FDB LAT6
       FDB LIT3
       FDB $80
       FDB TOG6
       FDB EXIT
```

(continued on next page)

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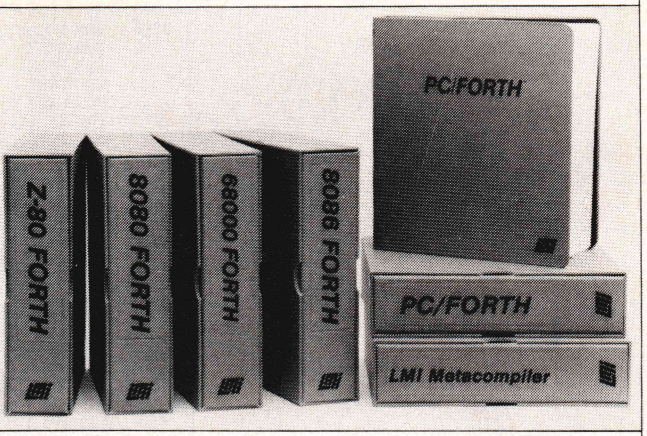

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Circle **no. 106** on reader service card.

Listing One (Listing continued, text begins on page 40.)

```
*
        FCB 5           -FIND
        FCC '-FI'
        FDB IMM9-6      link to IMMEDIATE
DFND    JMP DOCOL
        FDB BL2
        FDB WORD
        FDB CON7
        FDB FTCH
        FDB FTCH
        FDB FIN6
        FDB EXIT
*
        FCB 5           COUNT
        FCC 'COU'
        FDB DFND-6      link to -FIND
COU5    JMP DOCOL
        FDB DUP3
        FDB ONEP
        FDB SWAP
        FDB CFCH
        FDB EXIT
*
        FCB 1           0
        FCC '0 '
        FDB COU5-6      link to COUNT
ZERO    LDX SP
        CLRA
        DECX
        STA SP0,X
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 1           1
        FCC '1 '
        FDB ZERO-6      link to 0
ONE     LDX SP
        LDA #1
        DECX
        STA SP0,X
        DECX
        CLRA
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 1           2
        FCC '2 '
        FDB ONE-6       link to 1
TWO     LDX SP
        LDA #2
        DECX
        STA SP0,X
        CLRA
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 2           2+
        FCC '2+ '
        FDB TWO-6       link to 2
TWOP    LDX SP
        INCX            point to low
        LDA #2
        ADD SP0,X
        STA SP0,X
        DECX            point to high
        CLRA            A=0 note carry
        ADC SP0,X       is not affected
        STA SP0,X
        JMP NEXT
*
        FCB $81         [  (IMMEDIATE)
        FCC '[ '
        FDB TWOP-6      link to 2+
LBRAK   JMP DOCOL
        FDB ZERO
        FDB STA5
        FDB STO
        FDB EXIT
*
        FCB 1           ]
        FCC '] '
        FDB LBRAK-6     link to [
RBRAK   JMP DOCOL
        FDB LIT3
        FDB $C0
        FDB STA5
        FDB STO
        FDB EXIT
*
        FCB 11          DEFINITIONS
        FCC 'DEF'
        FDB RBRAK-6     link to ]
DEFS    JMP DOCOL
        FDB CON7
        FDB FTCH
        FDB CUR7
        FDB STO
        FDB EXIT
*
        FCB 1           +
        FCC '+ '
        FDB DEFS-6      link to DEFINITIONS
PLUS    LDX SP
        LDA SP0,X
        INCX
        STA PH
        LDA SP0,X
        INCX
        STX SP
        INCX            point to low on stack
        ADD SP0,X
        STA SP0,X
        LDX SP
        LDA PH
        ADC SP0,X
        STA SP0,X
        JMP NEXT
*
        FCB 1           -
        FCC '- '
        FDB PLUS-6      link to +
MINUS   LDX SP
        LDA SP0,X
        INCX
        STA PH
        LDA SP0,X
        INCX
        STA PL
        STX SP
        INCX            point to low on stack
        LDA SP0,X
        SUB PL
        STA SP0,X
        LDX SP
        LDA SP0,X
        SBC PH
        STA SP0,X
        JMP NEXT
*
        FCB 2           U*
        FCC 'U* '
        FDB MINUS-6     link to -
UMULT   LDX SP
        LDA SP0,X
        INCX
        STA PH
        LDA SP0,X
        INCX
        STA PL
        LDA SP0,X
        INCX
        STA QH
        LDA SP0,X
        STA QL
        STX XTEMP
        JSR MPY16
        LDX XTEMP
        LDA QL               push low word
        STA SP0,X
        LDA QH
        DECX
        STA SP0,X
        LDA TEMPB            push high word
        DECX
        STA SP0,X
        LDA TEMPA
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
SEC     EQU PH
*
DIV16   LDA SEC+2            Dividend: (H to L)
        LDX SEC              PL,PH,TEMPB,TEMPA
        STX SEC+2            (SEC +1,+0,+3,+2)
        LSLA
        STA SEC
        LDA SEC+3            Divisor is QH,QL
        LDX SEC+1
        STX SEC+3
        ROLA
        STA SEC+1
        LDA #$10
        STA TEMP
DBEG    ROL SEC+2
        ROL SEC+3
        LDA SEC+2
        SUB QL
        TAX
        LDA SEC+3
        SBC QH
        BCS DSKIP
        STX SEC+2
        STA SEC+3
        SEC
        BRA DSKIP+1
DSKIP   CLC
        ROL SEC         Quotient (H,L) is
        ROL SEC+1          SEC+1,SEC
        DEC TEMP        Remainder (H,L) is
        BNE DBEG           SEC+3,SEC+2
        RTS
*
        FCB 5           U/MOD
        FCC 'U/M'
        FDB UMULT-6     link to U*
UDMD    LDX SP
        LDA SP0,X
        INCX
        STA QH          divisor to Q
        LDA SP0,X
        INCX
        STA QL
        LDA SP0,X
        INCX
        STA SEC+1         high word to P
        LDA SP0,X         (SEC +1, +0)
        INCX
        STA SEC
        LDA SP0,X
        INCX
        STA SEC+3         low word to TEMPA/B
        LDA SP0,X         (SEC +3, +2)
        STA SEC+2
        STX SP
        BSR DIV16
        LDX SP
        LDA SEC+2         push remainder
        STA SP0,X         (HL: SEC+3, +2)
        LDA SEC+3
        DECX
        STA SP0,X
        LDA SEC           push quotient
        DECX              (HL: SEC+1, +0)
        STA SP0,X
        LDA SEC+1
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 4           S->D
        FCC 'S->'
        FDB UDMD-6      link to U/MOD
STOD    LDX SP
        LDA SP0,X
        TSTA
        BPL SPOS
        LDA #$FF
        BRA SEXIT
SPOS    CLRA
SEXIT   DECX
        STA SP0,X
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 3           PAD
        FCC 'PAD'
        FDB STOD-6      link to S->D
PAD     JMP DOCOL
        FDB HERE
        FDB LIT3
        FDB $0044
        FDB PLUS
        FDB EXIT
*
        FCB 2           <#
        FCC '<# '
        FDB PAD-6       link to PAD
LSHP    JMP DOCOL
        FDB PAD
        FDB HLD3
        FDB STO
        FDB EXIT
*
        FCB 4           OVER
        FCC 'OVE'
        FDB LSHP-6      link to <#
OVER    LDX SP
        INCX
        INCX
        LDA SP0,X
        INCX
```

```
        STA ATEMP
        LDA SP0,X
        LDX SP
        DECX
        STA SP0,X
        LDA ATEMP
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 2           #>
        FCC '#> '
        FDB OVER-6      link to OVER
SPGR    JMP DOCOL
        FDB DROP
        FDB DROP
        FDB HLD3
        FDB FTCH
        FDB PAD
        FDB OVER
        FDB MINUS
        FDB EXIT
*
        FCB 2           >R
        FCC '>R '
        FDB SPGR-6      link to #>
TOR     LDX SP
        LDA SP0,X
        INCX
        STA ATEMP
        LDA SP0,X
        INCX
        STX SP
        LDX RP
        DECX
        STA RP0,X
        LDA ATEMP
        DECX
        STA RP0,X
        STX RP
        JMP NEXT
*
        FCB 2           R>
        FCC 'R> '
        FDB TOR-6       link to >R
RTO     LDX RP
        LDA RP0,X
        INCX
        STA ATEMP
        LDA RP0,X
        INCX
        STX RP
        LDX SP
        DECX
        STA SP0,X
        LDA ATEMP
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 2           R@
        FCC 'R@ '
        FDB RTO-6       link to R>
RFTCH   LDX RP
        LDA RP0,X       pop high
        INCX
        STA ATEMP
        LDA RP0,X       pop low
        LDX SP
        DECX
        STA SP0,X       push low
        LDA ATEMP
        DECX
        STA SP0,X       push high
        STX SP
        JMP NEXT
*
        FCB 3           ROT
        FCC 'ROT'
        FDB RFTCH-6     link to R@
ROT     JMP DOCOL
        FDB TOR
        FDB SWAP
        FDB RTO
        FDB SWAP
        FDB EXIT
*
        FCB 4           HOLD
        FCC 'HOL'
        FDB ROT-6       link to ROT
HOLD    JMP DOCOL
        FDB LIT3
        FDB $FFFF        ( -1 )
        FDB HLD3
        FDB PLSTO
        FDB HLD3
        FDB FTCH
        FDB CSTO
        FDB EXIT
*
        FCB 5           M/MOD
        FCC 'M/M'
        FDB HOLD-6      link to HOLD
MDM5    JMP DOCOL
        FDB TOR
        FDB ZERO
        FDB RFTCH
        FDB UDMD
        FDB RTO
        FDB SWAP
        FDB TOR
        FDB UDMD
        FDB RTO
        FDB EXIT
*
        FCB 4           BASE
        FCC 'BAS'
        FDB MDM5-6      link to M/MOD
BAS4    JMP DOCOL
        FDB LIT3
        FDB BASE
        FDB EXIT
*
        FCB 6           SMUDGE
        FCC 'SMU'
        FDB BAS4-6      link to BASE
SMUDG   JMP DOCOL
        FDB LAT6
        FDB LIT3
        FDB $0020
        FDB TOG6
        FDB EXIT
*
        FCB 3           ABS
        FCC 'ABS'
        FDB SMUDG-6     link to SMUDGE
ABS     LDX SP
        LDA SP0,X
        TSTA
        BPL ABXIT
        COMA
        STA SP0,X
        INCX
        LDA SP0,X
        NEGA
        STA SP0,X
ABXIT   JMP NEXT
*
        FCB 2           0<
        FCC '0< '
        FDB ABS-6       link to ABS
ZLESS   LDX SP
        LDA SP0,X
        TSTA
        BPL ZLPOS
        LDA #$FF
        BRA ZLXIT
ZLPOS   CLRA
ZLXIT   STA SP0,X
        INCX
        STA SP0,X
        JMP NEXT
*
        FCB 2           0=
        FCC '0= '
        FDB ZLESS-6     link to 0<
ZEQ     LDX SP
        LDA SP0,X
        INCX
        ORA SP0,X
        BNE ZEN
        LDA #$FF
        BRA ZEXIT
ZEN     CLRA
ZEXIT   STA SP0,X
        DECX
        STA SP0,X
        JMP NEXT
*
        FCB 1           <
        FCC '<  '
        FDB ZEQ-6       link to 0=
LESS    JMP DOCOL
        FDB MINUS
        FDB ZLESS
        FDB EXIT
*
        FCB 1           >
        FCC '>  '
        FDB LESS-6      link to <
GREAT   JMP DOCOL
        FDB SWAP
        FDB LESS
        FDB EXIT
*
        FCB 1           =
        FCC '=  '
        FDB GREAT-6     link to >
EQUAL   JMP DOCOL
        FDB MINUS
        FDB ZEQ
        FDB EXIT
```

(continued on next page)

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Listing Two (Listing continued, text begins on page 40.)

```
*
        FCB 4             SIGN
        FCC 'SIG'
        FDB EQUAL-6       link to =
SIGN    JMP DOCOL
        FDB ZLESS
        FDB ZBRAN
        FDB $0008
        FDB LIT3
        FDB $002D
        FDB HOLD
        FDB EXIT
*
        FCB 6             NEGATE
        FCC 'NEG'
        FDB SIGN-6        link to SIGN
NEG6    LDX SP
        LDA SP0,X
        COMA
        STA SP0,X
        INCX
        LDA SP0,X
        NEGA
        STA SP0,X
        JMP NEXT
*
        FCB 2             +-
        FCC '+- '
        FDB NEG6-6        link to NEGATE
PIMI    JMP DOCOL
        FDB ZLESS
        FDB ZBRAN
        FDB $0004
        FDB NEG6
        FDB EXIT
*
        FCB 1             #
        FCC '#  '
        FDB PIMI-6        link to +-
SHARP   JMP DOCOL
        FDB BAS4
        FDB CFCH
        FDB MDM5
        FDB ROT
        FDB LIT3
        FDB $0009
        FDB OVER
        FDB LESS
        FDB ZBRAN
        FDB $0008
        FDB LIT3
        FDB $0007
        FDB PLUS
        FDB LIT3
        FDB $0030
        FDB PLUS
        FDB HOLD
        FDB EXIT
*
        FCB 2             OR
        FCC 'OR '
        FDB SHARP-6       link to #
OR2     LDX SP
        LDA SP0,X
        INCX
        INCX
        ORA SP0,X
        STA SP0,X
        DECX
        LDA SP0,X
        INCX
        INCX
        ORA SP0,X
        STA SP0,X
        DECX
        STX SP
        JMP NEXT
*
        FCB 3             AND
        FCC 'AND'
        FDB OR2-6         link to OR
AND3    LDX SP
        LDA SP0,X
        INCX
        INCX
        AND SP0,X
        STA SP0,X
        DECX
        LDA SP0,X
        INCX
        INCX
        AND SP0,X
        STA SP0,X
        DECX
        STX SP
        JMP NEXT
*
        FCB 3             XOR
        FCC 'XOR'
        FDB AND3-6        link to AND
XOR3    LDX SP
        LDA SP0,X
        INCX
        INCX
        EOR SP0,X
        STA SP0,X
        DECX
        LDA SP0,X
        INCX
        INCX
        EOR SP0,X
        STA SP0,X
        DECX
        STX SP
        JMP NEXT
*
        FCB 4             DDUP
        FCC 'DDU'
        FDB XOR3-6        link to XOR
DDUP    JMP DOCOL
        FDB OVER
        FDB OVER
        FDB EXIT
*
        FCB 2             #S
        FCC '#S '
        FDB DDUP-6        link to DDUP
SHRPS   JMP DOCOL
        FDB SHARP
        FDB DDUP
        FDB OR2
        FDB ZEQ
        FDB ZBRAN
        FDB $FFF6
        FDB EXIT
*
        FCB 1             .
        FCC '.  '
        FDB SHRPS-6       link to #S
DOT     JMP DOCOL
        FDB DUP3
        FDB DUP3
        FDB ABS
        FDB STOD
        FDB LSHP
        FDB SHRPS
        FDB ROT
        FDB SIGN
        FDB SPGR
        FDB TYPE
        FDB DROP
        FDB BL2
        FDB EMIT
        FDB EXIT
*
        FCB 7             COMPILE
        FCC 'COM'
        FDB DOT-6         link to .
COMP    JMP DOCOL
        FDB RTO
        FDB DUP3
        FDB TWOP
        FDB TOR
        FDB FTCH
        FDB COMA
        FDB EXIT
*
        FCB $81           ;  (IMMEDIATE)
        FCC ';  '
        FDB COMP-6        link to COMPILE
SEMI    JMP DOCOL
        FDB COMP
        FDB EXIT
        FDB SMUDG
        FDB LBRAK
        FDB EXIT
*
        FCB 1             :
        FCC ':  '
        FDB SEMI-6        link to ;
COLON   JMP DOCOL
        FDB CUR7
        FDB FTCH
        FDB CON7
        FDB STO
        FDB CRE6
        FDB SMUDG
        FDB COMP
        JMP DOCOL
        FDB RBRAK
        FDB EXIT
*
        FCB $81           '  (IMMEDIATE)
        FCB $27
        FCC '  '
        FDB COLON-6       link to :
TICK    JMP DOCOL
        FDB DFND
        FDB ZBRAN
        FDB $0006
        FDB DROP
        FDB EXIT
        FDB QUES
*
DOVAR   LDX SP
        LDA NEXT1+2       low byte of W
        ADD #3
        DECX
        STA SP0,X
        LDA NEXT1+1       high byte of W
        ADC #0
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 8             VARIABLE
        FCC 'VAR'
        FDB TICK-6        link to '
VAR8    JMP DOCOL
        FDB CRE6
        FDB LIT3          compile a jump
        FDB $00CC         to DOVAR
        FDB CCOMA
        FDB COMP
        FDB DOVAR
        FDB TWO
        FDB ALL5
        FDB EXIT
*
DOCON   LDA NEXT1+2       put W+2 into GET
        ADD #3
        STA GET+2
        LDA NEXT1+1
        ADC #0
        STA GET+1
        LDX #1
        JSR GET           get low byte of
                                constant
        LDX SP
        DECX
        STA SP0,X
        STX SP
        CLRX
        JSR GET           then the high byte
        LDX SP
        DECX
        STA SP0,X
        STX SP
        JMP NEXT
*
        FCB 8             CONSTANT
        FCC 'CON'
        FDB VAR8-6        link to VARIABLE
CON8    JMP DOCOL
        FDB CRE6
        FDB LIT3          compile a jump
                               to DOCON
        FDB $00CC
        FDB CCOMA
        FDB COMP
        FDB DOCON
        FDB COMA
        FDB EXIT
*
        FCB 1             *
        FCC '*  '
        FDB CON8-6        link to CONSTANT
MULT    JMP DOCOL
        FDB UMULT
        FDB DROP
        FDB EXIT
*
        FCB $89           [COMPILE]  IMMEDIATE
        FCC '[CO'
        FDB MULT-6        link to *
BCOM9   JMP DOCOL
        FDB TICK
        FDB COMA
        FDB EXIT
*
        FCB $85           BEGIN     IMMEDIATE
        FCC 'BEG'
        FDB BCOM9-6       link to [COMPILE]
BEGN    JMP DOCOL
        FDB HERE
        FDB EXIT
*
        FCB $85           AGAIN     IMMEDIATE
        FCC 'AGA'
        FDB BEGN-6        link to BEGIN
```

```
AGAIN  JMP DOCOL
       FDB COMP
       FDB BRAN
       FDB HERE
       FDB MINUS
       FDB COMA
       FDB EXIT
*
       FCB $85            UNTIL      IMMEDIATE
       FCC 'UNT'
       FDB AGAIN-6        link to AGAIN
UNTIL  JMP DOCOL
       FDB COMP
       FDB ZBRAN
       FDB HERE
       FDB MINUS
       FDB COMA
       FDB EXIT
*
       FCB $82            IF         IMMEDIATE
       FCC 'IF '
       FDB UNTIL-6        link to UNTIL
IF2    JMP DOCOL
       FDB COMP
       FDB ZBRAN
       FDB HERE
       FDB ZERO
       FDB COMA
       FDB EXIT
*
       FCB $84            THEN       IMMEDIATE
       FCC 'THE'
       FDB IF2-6          link to IF
THEN   JMP DOCOL
       FDB HERE
       FDB OVER
       FDB MINUS
       FDB SWAP
       FDB STO
       FDB EXIT
*
       FCB $84            ELSE       IMMEDIATE
       FCC 'ELS'
       FDB THEN-6         link to THEN
ELSE   JMP DOCOL
       FDB COMP
       FDB BRAN
       FDB HERE
       FDB ZERO
       FDB COMA
       FDB SWAP
       FDB THEN
       FDB EXIT
*
       FCB $85            WHILE      IMMEDIATE
       FCC 'WHI'
       FDB ELSE-6         link to ELSE
WHILE  JMP DOCOL
       FDB IF2
       FDB EXIT
*
       FCB $86            REPEAT     IMMEDIATE
       FCC 'REP'
       FDB WHILE-6        link to WHILE
REPET  JMP DOCOL
       FDB TOR
       FDB AGAIN
       FDB RTO
       FDB THEN
       FDB EXIT
*
       FCB 4              <.">
       FCC '<."'
       FDB REPET-6        link to REPEAT
BDOTQ  JMP DOCOL
       FDB RFTCH
       FDB COU5
       FDB DUP3
       FDB ONEP
       FDB RTO
       FDB PLUS
       FDB TOR
       FDB TYPE
       FDB EXIT
*
       FCB 3              TIB
       FCC 'TIB'
       FDB BDOTQ-6        link to <.">
TIB3   JMP DOCOL
       FDB LIT3
       FDB TIB
       FDB EXIT
*
       FCB 3              >IN
       FCC '>IN'
       FDB TIB3-6         link to TIB
FRIN   JMP DOCOL
       FDB LIT3
       FDB IN
       FDB EXIT
*
       FCB 7              'STREAM
       FCB $27
```

(continued on next page)

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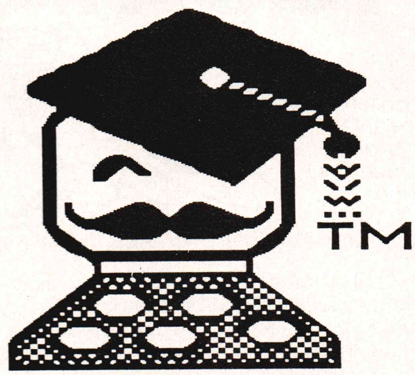

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Listing Two

(Listing continued, text begins on page 40.)

```
        FCC 'ST'
        FDB FRIN-6                  link to >IN
TSTRM   JMP DOCOL
        FDB TIB3
        FDB FRIN
        FDB CFCH
        FDB PLUS
        FDB EXIT
*
        FCB 4                        <DO>
        FCC '<DO'
        FDB TSTRM-6                  link to 'STREAM
BDO     LDA #4
        STA COUNTR
        ADD SP                       make 2 artificial pops
        STA SP
DOAGIN  LDX SP                       move limit
        DECX                         then index
        LDA SP0,X                    from SP
        STX SP                       to RP
        LDX RP
        DECX
        STA RP0,X
        STX RP
        DEC COUNTR
        BNE DOAGIN
        LDA #4                       adjust SP
        ADD SP
        STA SP
        JMP NEXT
*
        FCB 6                        <LOOP>
        FCC '<LO'
        FDB BDO-6                    link to <DO>
BLOP    CLR PH                     set increment to 1
        LDA #1
        STA PL
LOOPS   LDX RP                     increment index
        INCX                       by value
        LDA PL                     in P H/L
        ADD RP0,X
        STA RP0,X
        DECX
        LDA PH
        ADC RP0,X
        STA RP0,X
        INCX
        LDA RP0,X                test index-limit
        INCX
        INCX
        SUB RP0,X
        LDX RP
        LDA RP0,X
        INCX
        INCX
        SBC RP0,X
        EOR PH             also check increment sign
        BMI LAGIN          loop again if negative
        INCX
        INCX
        STX RP
        JMP ZBREX
LAGIN   JMP BRAN
*
        FCB 7                  <+LOOP>
        FCC '<+L'
        FDB BLOP-6             link to <LOOP>
BPLOP   LDX SP
        LDA SP0,X
        INCX
        STA PH                set increment
        LDA SP0,X             from the stack
        INCX
        STA PL
        STX SP
        BRA LOOPS
*
        FCB $82               DO           IMMEDIATE
        FCC 'DO '
        FDB BPLOP-6            link to <+LOOP>
DO      JMP DOCOL
        FDB COMP
        FDB BDO
        FDB HERE
        FDB EXIT
*
        FCB $84               LOOP          IMMEDIATE
        FCC 'LOO'
        FDB DO-6              link to DO
LOOP    JMP DOCOL
        FDB COMP
        FDB BLOP
        FDB HERE
        FDB MINUS
```

```
        FDB COMA
        FDB EXIT
*
        FCB $85              +LOOP        IMMEDIATE
        FCC '+LO'
        FDB LOOP-6           link to LOOP
PLOOP   JMP DOCOL
        FDB COMP
        FDB BPLOP
        FDB HERE
        FDB MINUS
        FDB COMA
        FDB EXIT
*
        FCB 7                DNEGATE
        FCC 'DNE'
        FDB PLOOP-6          link to +LOOP
DNEG7   LDA #3
        STA COUNTR
        LDX SP
DNLP    LDA SP0,X            ones complement
        COMA                 three bytes
        STA SP0,X
        INCX
        DEC COUNTR
        BNE DNLP
        LDA SP0,X            twos complement
        NEGA                 the fourth
        STA SP0,X
        JMP NEXT
*
        FCB $81              I   IMMEDIATE
        FCC 'I  '
        FDB DNEG7-6          link to DNEGATE
I1      JMP DOCOL
        FDB COMP
        FDB RFTCH
        FDB EXIT
*
*
*
*
           END

$
```

End Listings

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Listing One (Text begins on page 46.)

```
file: WINDOW.BLK        Block: 0

                                                  cl 11/10/85
window program
by
Craig A. Lindley
Manitou Springs
Colorado
November 1985

file: WINDOW.BLK        Block: 1

\ window routines                                 cl 11/10/85
\ window load screen

warning off

dark
.( Compiling window package and demo program )
cr

2 32 thru

warning on
```

```
file: WINDOW.BLK        Block: 2

\ case statement                                  cl 11/10/85
\ Dr. Charles Eakers Forth Dimensions Vol 2, Num 3
: ?comp    state @ not abort" Compilation only" ;
: ?pairs   <>          abort" Bad CASE statement"  ;

: case     ?comp csp @ !csp 4 ; immediate
: of       4 ?pairs
           compile over compile = compile ?branch
           here 0 , compile drop 5 ; immediate
: endof    5 ?pairs compile branch here 0 ,
           swap   >resolve 4 ; immediate
: endcase 4 ?pairs compile drop
           begin sp@ csp @ <>
           while >resolve repeat
           csp ! ; immediate
```

```
file: WINDOW.BLK        Block: 3

\ window routines                                 cl 11/10/85
\ write count # of chars with attrib at cursor position
code chra                        \ char/attrib count --
 cx pop ax pop ah bl mov         \ get count in cx, attrib in bl
 bh bh xor 9 # ah mov            \ char in al, func. code in ah
 si push 16 int si pop           \ do video interrupt
 next
end-code
\ write 1 char with attrib at cursor - update cursor position
code chra+                       \ char/attrib --
 ax pop ah bl mov bh bh xor      \ char in al, attrib in bl
 1 # cx mov 9 # ah mov           \ char in al, func. code in ah
 si push 16 int                  \ count=1, write char/attrib
 3 # ah mov 16 int dl inc 2 # ah mov 16 int
 si pop next                     \ inc cursor position
end-code
```

```
file: WINDOW.BLK        Block: 4

\ window routines                                 cl 11/10/85
\ read char and attrib at cursor position
code rdchra                      \ -- char/attrib
 0 # bh mov 8 # ah mov           \ pg =0  func. code = 8
 si push 16 int si pop           \ do video interrupt
 lpush                           \ char/attrib to stk
end-code

\ put char with attrib at x,y
: putch                          \ x y char/attrib --
  >r at r> 1 chra ;

\ get char with attrib at x,y
: getch                          \ x y -- char/attrib
  at rdchra ;
```

```
file: WINDOW.BLK        Block: 5

\ window routines                                 cl 11/10/85

\ draw count # of chars/attrib starting at x,y
: draw_row                       \ x y char/attrib count --
  >r >r at r> r> chra ;

\ scroll specified window up n lines
code scrlup                      \ xul yul xlr ylr cnt attrib --
 bx pop bl bh mov di pop         \ bh attrib si # of lines
 dx pop dl dh mov ax pop al dl mov \ dx has lr x y
 cx pop cl ch mov ax pop al cl mov \ cx has ul x y
 di ax mov si push bp push       \ save regs
 6 # ah mov 16 int               \ ax # of lines func. code ah
 bp pop si pop next              \ restore forth's regs
end-code
```

```
file: WINDOW.BLK        Block: 6

\ window routines                                 cl 11/10/85
\ memory management support
\ tell DOS to allocate memory bytes
code calloc                      \ # bytes -- seg T
 bx pop 4 # cl mov bx cl shr     \          -- maxp error code F
 bx inc 72 # ah mov 33 int       \ int 21h func. code 48h
 u< if   bx push ax push ax ax xor \ if C then error
    else ax push -1 # ax mov then lpush
end-code
\ tell DOS to free memory segment
code free                        \ seg -- T
```

(continued on page 98)

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Listing One (Listing continued, text begins on page 46.)

```
 ax pop ax es mov              \      -- error code F
 73 # ah mov 33 int            \ int 21h func. code 49h
 u< if   ax push ax ax xor     \ if C then error
    else -1 # ax mov then 1push
end-code
```

```
file: WINDOW.BLK        Block: 7

\ window routines                                    cl 11/10/85
\ memory management support
\ tell DOS to shrink or expand allociated memory segment

code setblock                  \ # bytes -- T
 cs ax mov ax es mov           \           -- maxp error code F
 bx pop 4 # cl mov bx cl shr   \ bx has # of paragraphs
 bx inc 74 # ah mov 33 int     \ int 21h func. code 4Ah
 u< if   bx push ax push ax ax xor \ if C then error
    else -1 # ax mov
    then 1push
end-code
```

```
file: WINDOW.BLK        Block: 8

\ window routines                                    cl 11/10/85
\ extended word fetch and store words
\ fetch word from extended memory
code e@                        \ seg addr -- n
 bx pop es pop                 \ seg in es addr in bx
 es: 0 [bx] ax mov             \ get the data on stk
 1push
end-code

\ store word in extended memory
code e!                        \ n seg addr --
 bx pop es pop ax pop
 ax es: 0 [bx] mov             \ store the data
 next
end-code
```

```
file: WINDOW.BLK        Block: 9

\ window routines                                    cl 11/10/85
\ read current cursor location

code rdcur                     \ -- x y
 si push 0 # bh mov 3 # ah mov \ int 10h func. code 3
 16 int  si pop ah ah xor
 dl al mov ax push dh al mov
 1push
end-code
```

```
file: WINDOW.BLK        Block: 10

\ window routines                                    cl 11/10/85
\ window control block (wcb) record layout
 0 constant ulx      2 constant uly           \ upper left corner
 4 constant width    6 constant height        \ width and height
 8 constant curx    10 constant cury          \ current cursor pos
12 constant oldx    14 constant oldy          \ old cursor pos.
16 constant bufseg  18 constant oldwcbseg     \ seg storage
20 constant attrib                            \ window attrib.

22 constant record_size                       \ size of record
15 constant boarder                           \ boarder attribute
hex
b800 constant v_seg                           \ video memory start
   variable wcbseg                            \ current wcb seg
decimal                                       \ storage
```

```
file: WINDOW.BLK        Block: 11

\ window routines                                    cl 11/10/85
\ extended memory fetch and store words

\ store word n at addr in current wcb
: wcbseg!                       \ n addr --
  wcbseg @ swap e! ;            \ store at addr in wcb seg

\ fetch word from addr in current wcb
: wcbseg@                       \ addr -- n
  wcbseg @ swap e@ ;            \ fetch from addr in wcb seg
```

```
file: WINDOW.BLK        Block: 12

\ window routines                                    cl 11/10/85
\ window frame drawing routines
: top
  ulx wcbseg@ uly wcbseg@ [ 201 boarder 256 * + ] literal putch
  ulx wcbseg@ 1+ uly wcbseg@ [ 205 boarder 256 * + ] literal
  width wcbseg@ draw_row
  ulx wcbseg@ width wcbseg@ + 1+ uly wcbseg@
  [ 187 boarder 256 * + ] literal putch ;
: bottom
  ulx wcbseg@ uly wcbseg@ height wcbseg@ + 1+
  [ 200 boarder 256 * + ] literal putch
  ulx wcbseg@ 1+ uly wcbseg@ height wcbseg@ + 1+
  [ 205 boarder 256 * + ] literal width wcbseg@ draw_row
  ulx wcbseg@ width wcbseg@ + 1+ uly wcbseg@ height wcbseg@ + 1+
  [ 188 boarder 256 * + ] literal putch ;
```

```
file: WINDOW.BLK        Block: 13

\ window routines                                    cl 11/10/85

\ window frame drawing routines
: sides
  uly wcbseg@ height wcbseg@ + 1+ uly wcbseg@ 1+
  do ulx wcbseg@ i [ 186 boarder 256 * + ] literal putch
     ulx wcbseg@ width wcbseg@ + 1+ i
```

```
    [ 186 boarder 256 * + ] literal putch
  loop ;
```

```
file: WINDOW.BLK       Block: 14

\ window routines                                      cl 11/10/85

\ temporary data storage areas
\ used by scn->buf and buf->scn

label save_h   nop nop          \ storage for height parameter
label save_w   nop nop          \ storage for width  parameter
label save_ptr nop nop          \ storage for start pointer
label save_si  nop nop          \ storage for forths IP reg
label save_ds  nop nop          \ storage for current ds reg
```

```
file: WINDOW.BLK       Block: 15

\ window routines                                      cl 11/10/85
\ move data from screen to memory buffer
hex
code scn->buf                    \ x y width height seg --
 cld es pop 0 # di mov save_h #) pop  save_w #) pop ax pop
 a0 # bl mov bl mul bx pop bx shl bx ax add ax save_ptr #) mov
 si save_si #) mov ds ax mov ax save_ds #) mov v_seg # ax mov
 ax ds mov cs: save_ptr #) si mov cs: save_h #) cx mov
 here cx push cs: save_w #) cx mov  rep movs
      cs: save_ptr #) si mov a0 # si add si cs: save_ptr #) mov
      cx pop
 loop
 cs: save_ds #) ax mov  ax ds mov
 save_si #) si mov
 next
end-code
```

```
file: WINDOW.BLK       Block: 16

\ window routines                                      cl 11/10/85
\ move data from memory buffer to screen
code buf->scn                    \ seg x y width height --
 cld  save_h #) pop  save_w #) pop ax pop  a0 # bl mov
 bl mul bx pop bx shl bx ax add ax save_ptr #) mov
 si save_si #) mov ds ax mov ax save_ds #) mov ax pop ax ds mov
 v_seg # ax mov ax es mov 0 # si mov cs: save_ptr #) di mov
 cs: save_h #) cx mov
 here cx push cs: save_w #) cx mov  rep movs
      cs: save_ptr #) di mov a0 # di add di cs: save_ptr #) mov
      cx pop
 loop
 cs: save_ds #) ax mov  ax ds mov   save_si #) si mov
 next
end-code
decimal
```

```
file: WINDOW.BLK       Block: 17

\ window routines                                      cl 11/10/85
\ lowest level window routine
```

(continued on next page)

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Listing One (Listing continued, text begins on page 46.)

```
\ moves screen data to memory buffer
\ and then draws the actual window frame

: ((window))                        \ move data scn->buf
  ulx wcbseg@ uly wcbseg@           \ x y coordinates
  width wcbseg@ 2+ height wcbseg@ 2+ \ width height
  bufseg wcbseg@ scn->buf           \ get buf seg addr
  top sides bottom ;
```

```
file: WINDOW.BLK        Block: 18

\ window routines                                  cl 11/10/85

\ clear window routine
: clr_window                        \ --
  ulx wcbseg@ 1+                    \ upper left  corner x
  uly wcbseg@ 1+                    \ upper right corner y
  ulx wcbseg@ width wcbseg@ +       \ lower left  corner x
  uly wcbseg@ height wcbseg@ +      \ lower right corner y
  0 attrib wcbseg@ scrlup           \ scroll entire window
  0 curx wcbseg!                    \ home window cursor
  0 cury wcbseg! ;
```

```
file: WINDOW.BLK        Block: 19

\ window routines                                  cl 11/10/85
: (window)                          \ x y width height attrib -- f
  record_size calloc                \ try to allocate space for wcb
  if wcbseg @ >r wcbseg ! r>        \ if successful store seg var
     oldwcbseg wcbseg! attrib wcbseg!   \ save attrib in wcb
     2dup 2+ swap 2+ * 2* calloc \ alloc space for screen buf
     if bufseg wcbseg!              \ save buffer seg
        height wcbseg! width wcbseg!    \ save parameters in
        uly    wcbseg! ulx   wcbseg!    \ new wcb
        rdcur oldy wcbseg! oldx wcbseg! \ get old cursor pos.
        ((window)) clr_window true      \ move data draw frame
     else ." buffer alloc. failure" cr  \ if no memory
       wcbseg @ free drop drop 0 \ free wcb memory
     then
  else ." wcb alloc. failure" drop drop 0
  then ;                                \ return flag
```

```
file: WINDOW.BLK        Block: 20

\ window routines                                  cl 11/10/85
\ window parameter checking
: wfit cr
  abort" Window won't fit on crt" ;
: open_window                       \ x y width height attrib -- f
  depth 5 >=
   if >r 4dup rot + 2+ 24 <=
     if + 2+ 79 <=
       if r> (window)
       else cr ." ULX and/or WIDTH incorrect" wfit
       then
     else    cr ." ULY and/or HEIGHT incorrect" wfit
     then
   else cr ." Incorrect # of parameters specified" quit
   then ;
```

```
file: WINDOW.BLK        Block: 21

\ window routines                                  cl 11/10/85
\ close the current window (defined by wcbseg data)
\ free wcb and buffer memory then unlink window
: close_window                      \ --
  wcbseg @ 0 <>                     \ if window exists
  if bufseg wcbseg@                 \ get buffer seg addr
     ulx wcbseg@ uly wcbseg@        \ get x,y corner
     width wcbseg@ 2+ height wcbseg@ 2+
     buf->scn                       \ mov data back to screen
     oldx wcbseg@ oldy wcbseg@ at
     bufseg wcbseg@ free drop       \ free buffer seg memory
     wcbseg @ free drop             \ free wcb seg memory
     oldwcbseg wcbseg@ wcbseg ! \ unlink this window
  else                              \ if no current window
     cr ." No open windows !" cr
  then ;
```

```
file: WINDOW.BLK        Block: 22

\ window routines                                  cl 11/10/85
\ position cursor in window
\ if parameters out of range do the best we can and still
\ stay in the window
: wat                               \ x y --
  swap dup abs width wcbseg@        \ req. x in window ?
  1- >                              \ if not then
  if drop width wcbseg@ 1- then     \ set x to max in window
  curx wcbseg!                      \ save new cursor x position
  dup abs height wcbseg@            \ req y in window ?
  1- >                              \ if not then
  if drop height wcbseg@ 1- then \ set y to max in window
  cury wcbseg!                      \ save new cursor y position
  curx wcbseg@ ulx wcbseg@ + 1+     \ actual cursor position
  cury wcbseg@ uly wcbseg@ + 1+     \ calculation
  at ;
```

```
file: WINDOW.BLK        Block: 23

\ window routines                                  cl 11/10/85
\ read window cursor position
: rdwcur                            \ -- x y
  curx wcbseg@ cury wcbseg@ ;

\ read char/attrib of character at cursor in window
```

```
: rdwcha                              \ x y -- char/attrib
  wat rdchra ;

\ scroll window up for blank line at bottom
: scroll_window                       \ --
  ulx wcbseg@ 1+ uly wcbseg@ 1+ \ upper left corner to scroll
  ulx wcbseg@  width wcbseg@ +  \ lower right x coordinate
  uly wcbseg@ height wcbseg@ +  \ lower right y coordinate
  1 attrib wcbseg@ scrlup ;     \ up 1 line
```

```
file: WINDOW.BLK       Block: 24

\ window routines                                    cl 11/10/85
\ do carrage return in the current window
: crout rdwcur nip 0 swap wat ; \ carrage ret in window

\ do a line feed in the current window
: lfout rdwcur 1+ dup
  height wcbseg@ 1- >           \ cursor out of window
  if 1- scroll_window then      \ if so scroll the window up
  wat ;                         \ place the cursor in window

\ do a back space in the current window
: bsout rdwcur over 0<>         \ backspace cursor in window
  if swap 1- swap wat then ;

\ ring the bell
: bell 7 (emit) ;               \ sound the horn
```

```
file: WINDOW.BLK       Block: 25

\ window routines                                    cl 11/10/85
: wemit dup 32 <                \ char --
  if case                       \ if control char process it
       7 of bell   endof        \ if bell then
       8 of bsout endof         \ if backspace then
      10 of lfout endof         \ if linefeed then
      13 of crout endof         \ if carrage ret then
     endcase
  else                          \ else its a display char
     attrib wcbseg@ 256 * +     \ char now char/attrib
     rdwcur rot chra+           \ output char adv. cursor
     drop dup width wcbseg@ 1- -   \ if at end of window line
     if drop lfout crout        \ do lfcr to next line
     else 1+ curx wcbseg!       \ store new x coordinate
     then
  then ;
```

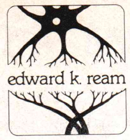
```
file: WINDOW.BLK       Block: 26

\ window routines                                    cl 11/10/85
: wcr 13 wemit 10 wemit ;       \ window carrage return

: wtype 0                       \ window equiv. of type
  ?do count wemit loop drop ;

\ use memory manager to give forth a full 64k segment
```

(continued on next page)



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FORTH WINDOWS

Listing One

(Listing continued, text begins on page 46.)

```
: initialize                            \ --
  cr ." Memory management "             \ output 1/2 msg
  -1 setblock                           \ request FFFF bytes
  if                                    \ if successful
    ." initialized"                     \ output message and
    0 wcbseg !                          \ initialize link variable
  else
    ." error" quit                      \ abort program
  then cr ;
```

```
file: WINDOW.BLK        Block: 27

\ window demo                                              cl 11/10/85
\ window equivalents of standard Forth words

: wlist block 16 0
  do dup i c/l * + c/l                  \ window equiv. of list
     -trailing wtype wcr
  loop drop ;

: wtriad 3 / 3 * 3 bounds               \ window equiv. of triad
  do i wlist                            \ list screen in window
     wcr wcr                            \ add a couple of cr's
  loop ;
```

```
file: WINDOW.BLK        Block: 28

\ window demo                                              cl 11/10/85
\ window canned messages
: msg1
  " This could be your application program! " wtype ;
: msg2 " Ain't this window package something! " wtype ;
: msg3 "  ** Window 4 ** " wtype ;

: msg1out 0 0 wat                       \ output msg1 20 times
  20 0 do msg1 loop ;

: msg2out 0 0 wat                       \ output msg2 10 times
  10 0 do msg2 loop ;

: msg3out 0 0 wat                       \ output msg3 80 times
  80 0 do msg3 loop ;
```

```
file: WINDOW.BLK        Block: 29

\ window demo                                              cl 11/10/85
\ video attribute constants
7   constant normal          15 constant high_int
112 constant reverse         128 constant blink

: fill_crt 0 0                          \ fill crt with rev video A's
  [ ascii A reverse 256 * + ]           \ calculate char/attrib code
```

```
  literal 2048 draw_row ;

: wait 10000 0 do noop loop ;    \ timing loop
```

```
file: WINDOW.BLK        Block: 30

\ window demo                                           cl 11/10/85
\ define the four windows used in the demo program

: window1                        \ define window #1
  0 0 20 10 reverse open_window ;

: window2                        \ define window #2
  2 1 70 8 normal open_window ;

: window3                        \ define window #3
  7 6 69 10 reverse open_window ;

: window4                        \ define window #4
  10 9 59 4 high_int open_window ;
```

```
file: WINDOW.BLK        Block: 31

\ window demo                                           cl 11/10/85
: demo
  fill_crt window1
 if 0 0 wat msg2 wait wcr wait 7 emit wcr
    wait " It sure is" wtype wait 8 wemit 8 wemit
    wait 10 5 wat wait window2
    if msg1out wait window3
       if 0 10 wat 24 wtriad wait window4
          if msg3out wait close_window wait close_window
             wait clr_window msg2out wait close_window
             0 wlist wait wait wait wait close_window
          then
       then
    then
 then
 wait ;
```

```
file: WINDOW.BLK        Block: 32

\ window demo                                           cl 11/10/85
only forth also dos also         \ search dos and forth
: test empty-buffers             \ dummy program name
  initialize                     \ initialize memory manager
  " window.blk"  fcb1 (!fcb)     \ parse filename to fcb
  fcb1 !files open-file          \ open the file to list
  2 0
  do                             \ run the demo 2 times
    demo wait wait wait dark wait
  loop
  ." What did you think of that Huh?" cr bye ;

only forth also                  \ power up search order

' test is boot                   \ make demo run automatically
save-system window.com           \ create .COM demo
```

End Listing

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Listing One (Text begins on page 112.)

```
Listing One:  tiny tools

: NIP   ( n m - m )        SWAP DROP ;   ( drops second on stack  )
: TUCK  ( n m - m n m )    SWAP OVER ;   ( tucks top under second )
: -ROT  ( a b c - c a b )  ROT ROT ;     ( opposite of ROT )

: INCR  ( a - )   1 SWAP +! ;    ( increments a variable )
: DECR  ( a - )  -1 SWAP +! ;    ( decrements a varaible )

  ( ERRCNT INCR increments the variable ERRCNT )
  ( #LINES DECR decrements the variable #LINES )

: ON    ( a - )  -1 SWAP ! ;   ( forces variable to true value )
: OFF   ( a - )   0 SWAP ! ;   ( forces variable to false value )

   27 CONSTANT ESC

: NUF? ( - f ) ?TERMINAL DUP IF KEY 2DROP KEY ESC = THEN ;

  ( NUF? is used inside a DO LOOP structure; when a key is   )
  ( pressed, NUF? stops to wait for a second keypress.        )
  ( If no key was struck or the second key is not the Escape  )
  ( key, the flag is false; otherwise, the flag is true.      )

  ( The word ?TERMINAL is vendor-specific.  Your Forth might  )
  ( use ?KEY or some other word instead.  It is the word that )
  ( returns a true flag if a key has been pressed and a false )
  ( flag otherwise; the key's value is then retrieved with the)
  ( standard word KEY. )

: LISTIT  #LINES 0 DO I LIST-LINE NUF? IF LEAVE THEN LOOP ;

 ( Example of NUF?:  LISTIT will pause after listing a line )
 ( when a key is pressed.  Pressing Escape will then leave  )
 ( the loop, interrupting the task; any key except Escape   )
 ( does not interrupt but resumes the task. )

   0 CONSTANT F
  -1 CONSTANT T

: ESC-HIT? ( - f ) ( leaves T if Escape key pressed )
   F ?TERMINAL IF BEGIN KEY ESC = OR ?TERMINAL NOT UNTIL THEN ;

 ( ESC-HIT? is like NUF? without the pause.  It is used much )
 ( like NUF? and would also work in the above example.  Note )
 ( that ESC-HIT? discards the contents of the key buffer as  )
 ( it rummages through looking for an Escape keypress.       )

: BYTE-SWAP ( x - x' ) 256 UM* OR ;

 ( This word swaps the two bytes in a cell.  Bill Muench of  )
 ( Santa Cruz thought of this little gem. )
```

End Listing One

Listing Two

```
Listing Two: array-defining word 1

: ARRAY  CREATE ( # - ) 2* ALLOT    ( reserves # cells in memory )
         DOES>  ( n <adr> - adr ) SWAP 2* + ; ( adr of nth cell )

( This array allocates the number of cells specified, but does )
( not initialize them to zero. )

  8 ARRAY TOM    ( defines TOM as having 8 cells = 16 bytes )
  125 5 TOM !    ( stores 125 in cell 5 of TOM )
  0 TOM @        ( retrieves the contents of cell 0 of TOM )
```

End Listing Two

Listing Three

```
Listing Three:  array-defining word 2

  1 CONSTANT BYTES
  2 CONSTANT CELLS
  4 CONSTANT DOUBLES

: FOR   CREATE ( #slots type - ) DUP C, * HERE OVER ERASE ALLOT
        DOES>  ( index <adr>  - adr ) COUNT ROT * + ;

  11 BYTES FOR FRED
  35 CELLS FOR JOAN
  17 DOUBLES FOR JOHN

 ( These arrays will deliver the address of the slot based  )
 ( on the type of the entry.  The array is initialized to   )
 ( zeroes at creation time.  It is the programmer's job to  )
 ( use C!, !, 2!, C@, @, and 2@ as appropriate.  Note that  )
 ( FRED's 11 slots are numbered 0 through 10, JOAN's 35 are )
 ( numbered 0 through 34, and JOHN's 17 are 0 through 16.   )

  213 3 FRED C!         ( stores 213 into byte 3 of FRED )
  31 JOAN @             ( fetches contents of cell 31 of JOAN )
  3142352. 15 JOHN 2!   ( stores 3142352. into slot 15 of JOHN )
```

End Listing Three

Listing Four

```
Listing Four:  array-defining word 3

  1 CONSTANT PUT    ( flags for the IF statement )
  0 CONSTANT GET    ( in the DOES> part of FOR   )

  CREATE STORES     ] C! ! NOOP 2! [   ( NOOP stored to put 2! )
  CREATE FETCHES    ] C@ @ NOOP 2@ [   ( and 2@ in right spot  )

: FOR   CREATE ( #slots type - ) DUP C, * HERE OVER ERASE ALLOT
        DOES>  ( datum 1 ndx <adr> --   |   0 ndx <adr> -- datum )
           COUNT DUP >R ( save type ) ROT * +   R> 1- 2*   ROT
              IF STORES  ELSE FETCHES  THEN  + @ EXECUTE ;

 ( This version of FOR takes care of the fetching and storing  )
 ( given the appropriate flag; the programmer does not have to )
 ( remember whether it is a byte, cell, or double-precision    )
 ( array.  This could easily be extended for floating-point    )
 ( numbers as well. In the stack comment, "|" is read as "or." )

  11 BYTES FOR FRED
  35 CELLS FOR JOAN
  17 DOUBLES FOR JOHN

  213 PUT 3 FRED         ( stores 213 in byte 3 of FRED )
  GET 31 JOAN            ( retrieves contents of cell 31 of JOAN )
  3142352. PUT 15 JOHN   ( stores 3142352. in slot 15 of JOHN )
```

End Listing Four

Listing Five

```
Listing Five:  bit tools

  CREATE BITBYTES  1 C, 2 C, 4 C, 8 C, 16 C, 32 C, 64 C, 128 C,

: FLAG  ( ? - f ) 0= NOT ; ( forces to a Boolean flag: -1 or 0 )

: AIM   ( # adr - bit# adr' ) SWAP 8 /MOD ROT + ;

: +BIT  ( # adr - ) AIM SWAP MASK OVER C@  OR SWAP C! ;

: -BIT  ( # adr - ) AIM SWAP MASK NOT OVER C@ AND SWAP C! ;

: @BIT  ( # adr - f ) AIM C@ SWAP MASK AND FLAG ;

: ~BIT  ( # adr - f ) AIM 2DUP @BIT IF -BIT ELSE +BIT THEN ;
```

End Listing Five

Listing Six

```
Listing Six:  array-defining word 4

  0 CONSTANT BITS        ( for bit arrays )

: BITS>BYTES  ( #bits - #bytes ) 8 /MOD SWAP IF 1+ THEN ;

: FOR    CREATE ( #slots type - ) DUP C, ?DUP
            IF *   ELSE BITS>BYTES   THEN
            HERE OVER ERASE ALLOT
         DOES> ( datum 1 ndx <adr> --   |   0 ndx <adr> -- datum )
            COUNT ?DUP   ( nonzero = numbers; 0 = bits )
            IF DUP >R ( save type )  ROT * +  R> 1- 2*  ROT
               IF STORES  ELSE FETCHES  THEN  + @ EXECUTE
            ELSE  ROT ( action flag: 1 = store, 0 = fetch  )
               IF ROT ?DUP  ( nonzero means 1 bit or toggle )
                  IF 0<  IF ~BIT  ELSE +BIT THEN
                  ELSE -BIT THEN
               ELSE @BIT THEN THEN ;

  1 1   2CONSTANT SET     ( By placing two values on  )
  0 1   2CONSTANT ZAP     ( the stack, these words in )
 -1 1   2CONSTANT FLIP    ( effect include the PUT.   )

 23 BITS FOR BIT     ( reserves 4 bytes for bit array )

  SET 16 BIT     ( turns bit 16 on )
  ZAP  5 BIT     ( turns bit 5 off )
  FLIP 0 BIT     ( toggles bit 0    )

  GET 3 BIT      ( retrieve bit 3 as boolean flag )

 ( Examples shown in Listing 4 will also work with this word.)
```

End Listing Six

Listing Seven

```
Listing Seven:  array-defining word 5

: >TYPE  ( adr - adr' ; from #slots-adr to type-adr )  2+ ;

: >DATA  ( adr - adr' ; from #slots-adr to data-adr )  3 + ;

: FOR   CREATE ( #slots type - )
              OVER , ( #slots )   DUP C, ( type )  ?DUP
              IF *   ELSE BITS>BYTES   THEN
              HERE OVER ERASE ALLOT
        DOES> ( datum 1 ndx <adr> --  |  0 ndx <adr> -- datum )
              >TYPE COUNT ?DUP ( nonzero = numbers; 0 = bits )
              IF DUP >R ( save size ) ROT * + R> 1- 2* ROT
                 IF STORES  ELSE FETCHES  THEN  + @ EXECUTE
              ELSE  ROT ( action flag:  1 = store, 0 = fetch )
                 IF ROT ?DUP ( nonzero means 1 bit or toggle )
                    IF 0< IF ~BIT ELSE +BIT THEN
                    ELSE -BIT THEN
                 ELSE @BIT THEN THEN ;
```

End Listing Seven

Listing Eight

```
Listing Eight:  array display word

: "TYPES ." bit   byte  cell        double" ;

: .TYPE ( type - ) 6 * ['] "TYPES >BODY 3 + + 6 -TRAILING TYPE ;

: DOUBLE? ( type - f ) 4 = ;

: }LINE   ( type n - type ) OVER DOUBLE?  IF DUP 5  ELSE DUP 10
    THEN   MOD  IF DROP  ELSE CR 4 .R ."  | " THEN ;

: VITALS ( array-adr - data-adr #slots type ) DUP >TYPE
    OVER >DATA ROT @ ( #slots ) ROT C@ ( type ) ;

: TITLE  ( #slots type - ) CR CR SWAP . .TYPE ." s:" ;

: DISPLAY ( adr -- )  VITALS 2DUP TITLE  ?DUP
    IF ( numbers ) SWAP 0 DO I }LINE 2DUP I * + ( adr )
        OVER DUP >R ( save type ) 1- 2* FETCHES + @ EXECUTE
        R> DOUBLE?   IF 12 D.R   ELSE 7 .R   THEN
        NUF? IF LEAVE THEN LOOP 2DROP
    ELSE ( bits ) 0 DO I DUP }LINE OVER @BIT
        2 SPACES  IF ASCII 1  ELSE ASCII -  THEN EMIT
        NUF? IF LEAVE THEN LOOP DROP
    THEN CR ;

: SPILL ( - ; name ) BL WORD FIND
   IF   >BODY DISPLAY
   ELSE DROP CR ." No such array " THEN ;


16 DOUBLES FOR MIKE
1892735. PUT  0 MIKE
7802472. PUT 15 MIKE
1263.    PUT  8 MIKE
SPILL MIKE

16 doubles:
  0 |      1892735           0           0           0           0
  5 |            0           0           0        1263           0
 10 |            0           0           0           0           0
 15 |      7802472

16 BITS FOR STEVE
SET  0 STEVE
SET 15 STEVE
FLIP 11 STEVE
SPILL STEVE

16 bits:
  0 |  1  -  -  -  -  -  -  -  -  -
 10 |  -  1  -  -  -  -  1
```

End Listings

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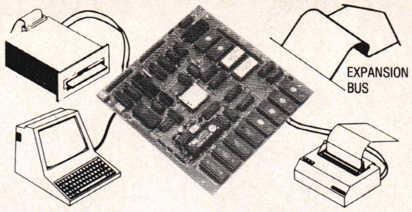

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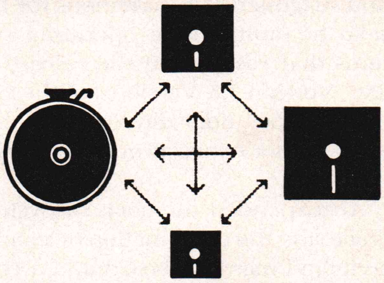

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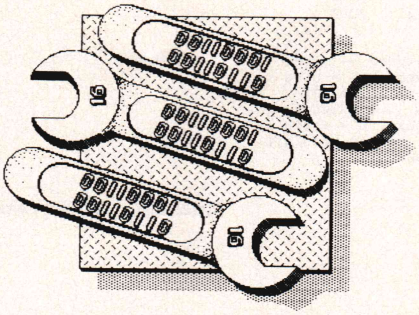

by Ray Duncan

Forth and the EMS

The Lotus/Intel/Microsoft Expanded Memory Specification (EMS) allows application programs to access as much as 8 megabytes of bank-switched memory in a portable manner. The original specification (Version 3.0) was released jointly by Intel and Lotus around the time of the spring Comdex in 1985. Subsequently, Microsoft endorsed the EMS and suggested some additions for the sake of multitasking operating systems that resulted in the release of EMS, Version 3.2. Version 4 of the EMS is said to be under development, but we will not concern ourselves with that here.

An expanded memory subsystem is actually the combination of a bank-switched memory board and a resident system driver. Taken together, these present a uniform interface that can be called by programs via a software interrupt (*67H*). The driver supports such functions as allocation, deallocation, and mapping of the expanded memory pages. The Above Board from Intel was the first commercially available implementation of the EMS, but EMS boards are now available from a broad variety of vendors, including AST, Quadram, and Tall Tree Systems. Expanded memory should not be confused with *extended memory*, which is IBM's term for the physical memory above 1 megabyte that is addressable by an 80286 CPU running in protected mode.

In harmony with this *DDJ* issue's emphasis on Forth, I have included the source code for a simple PC/Forth interface to an expanded memory subsystem, allowing the declaration and use of huge arrays (Listing One, next month). I have kept the code simple for clarity and have made no attempt to optimize it for speed. Also, for the purposes of this example, I have not taken advantage of the EMS driver's ability to map four separate logical pages onto physical memory at a time, and I have not included code to eliminate redundant mapping calls. As they say in the calculus books, these enhancements are left as an exercise for the reader, though they are easy to add once the basic EMS scheme is understood.

Readers wishing for more details about EMS programming can find them in the chapter on memory management in my book *Advanced MS-DOS* (Bellevue, WA: Microsoft Press, 1986). You can also obtain the original EMS document (part number 300275-003, dated September 1985) from Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051.

The TEE Filter Again

Herb Shear, of Los Altos, California, wrote: "Just a couple of comments regarding the TEE filter (published in the April 1985 *DDJ*). In the August issue you mention a bug reported by Dr. Fred Sinal, who indicated that the problem occurred with files that did not end in a *CR/LF*. The actual problem is with files ending with the infamous Control-Z being output to the console in cooked mode. The resultant stripping of the ^Z leaves the count one short, implying a 'disk full' to the calling program.

"My first fix was to use the returned count as an offset pointer into the buffer and to test the character for ^Z. If the compare was true, it was considered a good excuse for the failed write and the jump to the error message was not executed. This was OK, except that with midfile ^Zs, the latter part of the file never got to the console, though a file large enough to reload the buffer would cause console output to resume. The disk file output would be complete. Acceptable but rather ungainly behavior.

"My second fix was to test the device attribute word for the output device with the *IOCTL* function and to set the output device to raw mode if it was found to be the console. Because the console's mode is remembered program to program, it must be restored before TEE exits."

Gary Woodman, of Darwin, Australia, wrote: "Using PC-DOS, I normally redirect the output from BACKUP into a file to keep a log of what was backed up and when. BACKUP is even duller than usual when there's no output on the screen, however.

"I gleefully recalled the TEE filter you published in the April 1985 issue and chuckled to myself: 'Ah ha, I'll TEE the output of BACKUP both to a file and to the screen!' But when I dug out the issue, it seemed like too much trouble to type in a couple of pages of 8086 assembler (it usually does), so I scratched my head for a few moments and came up with a short C program [Table 1, below].

"Now I know this is not quite the same as that Mr. Head provided, and I don't want to make a big thing of this, but it seems that the contrast between Mr. Head's MASM program and this C program represents, in a nutshell, the dichotomy of programming today. As well as contrasting

```
#include <stdio.h>
main( )
{       int c;
        while ( (c  =  fgetc(stdin) )  !=
                                        EOF){
                fputc(c,  stdout);
                fputc(c,  stderr);
        }
}
```

Table 1: *C version of TEE filter*

the source code, contrast Mr. Head's hours (possibly days) of development plus an hour of my time to type in and debug TEE.ASM (that is, debug my typing!) with the few minutes it took me to write the C program. . . . Could it be that we have here a case of the tail wagging the dog?

"Just in passing, in case anyone still feels that high-level language compilers add flab to our programs but little else, I report the code sizes of TEE.EXE as generated by my three MS-DOS compilers:

Computer Innovations, V. 1.31	7,936 bytes
DeSmet, V. 2.41	8,192 bytes
Hi-Tech, V. 2.0	1,611 bytes

"Incidentally, this version of the CI compiler is now in the public domain, a brilliant marketing ploy and a 'best buy.'

"I haven't done any benchmarks as it really isn't a very important issue. Everyone knows the assembler program leads by at least an order of magnitude. For the number of times I TEE things, I'm quite happy to accept the run-time inefficiencies in exchange for the saving in development using C for what is almost a disposable program. And as for TEEing the output of BACKUP, well, MS-DOS is of course single-tasking and, as it turns out, the output of BACKUP is not available to TEE until BACKUP finishes."

Mr. Woodman's points on coding time vs. execution time are certainly worth discussing further in this column. It doesn't take me more than an hour or two to write a program the size of TEE from scratch in assembly language and feel confident that it is adequately debugged. And the vast majority of assembly code is reusable, just as is C or any other language. Once an assembly-language functioning filter such as TEE is in hand, for example, it is only a few minutes' work to modify it to perform any reasonable transformation on a character stream. For me, the benefits of the superior performance and compactness of an assembly-language program almost always outweigh all other considerations for utility programs that I am going to run more than once. Let's hear from *DDJ* readers on this subject!

Incidentally, I suspect that if Unix

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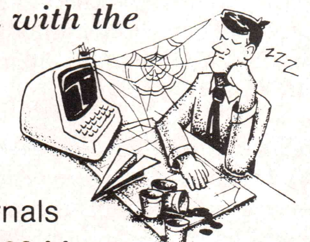

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(continued from page 107)

were written in assembly language instead of in C, it would have an overhead of 64K instead of 256K, would run ten times faster, and wouldn't be so overburdened with barely useful features that have been grafted on by generations of graduate-student programmers at UC Berkeley.

Defenders of Concurrent DOS

My (perhaps somewhat overdrawn) editorializations about Concurrent DOS and Digital Research in the February 1986 issue of *DDJ* drew plenty of responses from readers. This month I'd like to give some space to other viewpoints on this product.

Steve Elias, of Wellesley Hills, Massachusetts, wrote heatedly: "Look before you write that Concurrent DOS only supports DOS 1 functionality. You were using an old version. Concurrent DOS supports all 2.1 calls.

"Concurrent DOS is the most sophisticated and DOS-compatible multitasking operating system available. The fact that it is based on CP/M may be ugly, but it is transparent to the average user."

Mark Davidson of Chattanooga, Tennessee, sent two separate, detailed letters on Concurrent DOS 4.1, which I have abstracted to some extent: "The new version really only supports path names as far as the *CHDIR*, *RMDIR*, and *MKDIR* commands go. None of the Concurrent PC-DOS commands will accept a directory path. . . . As for using your DOS utilities under Concurrent DOS, it depends on what version of DOS these utilities belong to. If you are using PC-DOS 3.0 when you install Concurrent DOS, you can forget about running any of your PC-DOS utilities. They all refuse to run, giving the 'incorrect DOS version' message. The story is a little different if you are using PC-DOS 2.1. Some utilities will run fine (such as TREE and FIND), whereas others do things that are very unexpected (CHKDSK checks drive A: instead of the current drive). DRI warns that BACKUP and RESTORE should not be used. Also, it claims that you can run BASICA under Concurrent DOS with the only side effect being that multiuser activity will halt. This appears to be an understatement. BASICA on the PC/AT using the BASICA that comes with PC-DOS 3.1 will produce the 'incorrect DOS version' error. My attempts to run BASICA from PC-DOS 2.1 under Concurrent DOS produced an interesting display of nothing while causing a horrendous beeping to come from the speaker.

"I found some other unexpected surprises, too. Commands such as *type foo.doc ¦ more* will type the file but not pause at the end of each screenful. Could this mean that pipes don't work? Also, because none of the PC-DOS 3 commands will run under Concurrent DOS, attempts to execute the Version 3 command.com as a subprocess will fail. I haven't tried this with the PC-DOS 2.1 command.com.

"But this letter isn't full of just bad news. DRI has obviously fixed some of the problems that were present in Concurrent DOS 3.2. Many programs that wouldn't execute under 3.2 now run fine under 4.1—these include the Lattice C compiler and DeSmet's C compiler. Also, because some of the PC-DOS 2.1 utilities at least try to run, it is evident that several internal changes have been made. . . .

"Concurrent DOS is still noticeably slower than PC-DOS, even if you have only one task running. And it is a big system, still requiring approximately 1,700K of disk space; DRI also suggests that you have at least 512K RAM in your machine."

Brian J. Mullan of Lutz, Florida, sent an articulate defense of Concurrent DOS and its capabilities (both present and future). He wrote: "I am a senior software systems analyst with a company based in McLean, Virginia, and I would like to provide some comments regarding your editorial statements on Digital Research's Concurrent DOS operating system.

"IBM has just implemented DRI's Concurrent DOS 286 as the host IBM PC/AT OS for a 128-terminal system that it is going to market under the system 4680 name. I don't know how much you read in other professional trade magazines, but the IBM representatives who commented on the release of the 4680 system stated in an *MIS Week* issue three or four weeks ago that 'this is a true multitasking/multiuser operating system allowing IBM PC software to run in the IBM PC/ATs protected mode.'

"IBM also stated that it had worked with DRI to develop Concurrent DOS 286 and to allow it to run PC-DOS software in the AT's protected mode! The single AT running this OS not only provides the horsepower to manage the 128 dumb terminals tied to it (note: this system is not a LAN!), but the multitasking capabilities of the system allow on-line communications to an IBM mainframe host concurrently with other processing functions.

"So first of all, it is not true that DRI gave up on the 80286 Protected Mode version of its OS. Where is Microsoft's? [I didn't say DRI had given up on it, I said it admitted the OS would not be delivered in the form originally advertised.]

"The mention you made of the DRI Unix events are not quite accurate either. . . . According to the trade media coverage (by *Computerworld* and *MIS Week*), AT&T was the cause of the breakoff of the DRI Unix library development effort. Apparently AT&T decided that the Unix library needs could not possibly be fullfilled by a single company (which I think you should note included AT&T Informations Systems division) in the time necessary to bring AT&T's computer line up against IBM. Because AT&T had signed an exclusive agreement with DRI for the development of this library, this prohibited AT&T from parceling out the tremendous amount of work to be done to even a single other company. So it was at AT&T's request that the contract was canceled and with the acknowledgement that DRI was not delinquent in its contractual obligations to AT&T.

"Again, AT&T did not go to Microsoft for this development work, which should also make some sort of a statement!

"Last, Digital Research's Concurrent DOS version for the IBM PC/XT is the only true multitasking/multiuser, PC-DOS-compatible OS for those machines. Yes, there is Xenix (no DOS compatibility), which costs only seven times as much and takes up 6-8 megabytes of disk storage space vs. the 160K for Concurrent DOS.

"I am also a Unix advocate and have programmed under that OS for several years now. At home, however, I use Digital Research's Concurrent PC-DOS, Version 4.1. I find it to be a very good operating system environment with nearly all the profes-

sional systems design concepts described as essential for modern computing by such books as *Operating System Elements—A User Perspective* by Peter Calingaert (Prentice-Hall). Among the state-of-the-art features pointed out in this book that Concurrent PC-DOS provides and MS-DOS does not are:

- the concept of programs as finite-state processes within the computer
- dynamic memory management in the multitasking/multiuser environment
- systems support for QUEUEING structures (that is, interprocess message queues, priority queues, mutual exclusion queues, and so on)
- support for multilevel PRIORITY assignment to allow efficient scheduling of multiple concurrent processes
- inclusion of a directory hashing algorithm (which drastically increases system throughput)
- logical file and record locking
- multilevel passwording of files controlling read, write, and delete privileges
- time and date stamping of files (for creation, last access, and last modification)
- system support for processes to issue logical *wait* or *resume* interrupts—another efficient method used in interprocess communications
- real-time multitasking and multiuser support (note that Microsoft Windows uses a nonpreemptive multitasking algorithm, which means it cannot be used for applications requiring real-time response)
- logical data storage elements
- the ability to spawn multiple subprocesses from any single process (invaluable for any application that must monitor multiple port I/O such as in communications or instrumentation control)

"I agree and disagree with your statement that DRI will always be playing catch-up to Microsoft's MS-DOS. I believe that if you consider the features that DRI's PC-DOS-compatible OS family (which by the way runs on the 8088, 8086, 80286, and 68000) already provides, and which Microsoft is only now beginning to address for its MS-DOS, you might take a different attitude as to which operating system really provides the professional pro-

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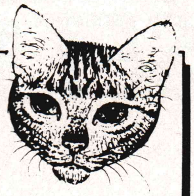

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16-BIT
(*continued from page 109*)

grammer with the more state-of-the-art programming environment!

"Yes, DRI is playing catch-up but only in an attempt to maintain file and programming compatibility with MS-DOS as Microsoft attempts to implement all of the aforementioned features. DRI's next release of the PC/XT version of this OS in two to three months and which is already in beta testing should provide the last vestiges of compatibility with MS-DOS, Version 2.1, including:

- full path support
- installable device drivers (the current version allows only hard-disk device drivers to be installed dynamically)
- DOS environment variable support via MS-DOS *set* command

"An extension to the version of the OS currently in beta testing, scheduled for summer 1986, is supposed to provide full MS-DOS, Version 3.1, compatibility!

"After all, if DRI has learned any lesson from the past four years, it has been that the public has been sold on the MS-DOS environment, and DRI must provide that functionality in its systems software. This only indicates to me that DRI is responding to the marketplace and if anything is looking backward to Microsoft's limited OS to see how it can be supported.

"Many a systems engineer will support the theory that a good operating system must be designed from the beginning to incorporate the structures necessary for real-time multiuser/multitasking. Attempting to do otherwise invites development of a most haphazard and kludged design in the attempt to maintain compatibility with whatever the current operating system provides. I think this problem with MS-DOS will become more evident as Microsoft attempts to introduce multitasking and multiuser support to its OS. I think it is relevant and most significant to notice that Microsoft did not provide its first attempt at multitasking through its operating system but through an externally run program—Windows.

"Although it is true that DRI has made several heroic blunders in the past, I do not believe they should be held as some sort of crucifix for it to bear. Everyone makes mistakes, and I do believe that DRI has and still is paying for its! I also believe, however, that it is the duty of columnists such as yourself to keep an open mind and to provide information that benefits the computing public at large and not to blindly assume such things as MS-DOS' a priori superiority of design.

"You must remember that 90 percent of all businesses in the United States are small businesses that only have need for two to five terminal users. LANs are great and very cost-effective for six or more users, but for small businesses, a multiuser operating system that allows the attachment of $400–$500 dumb terminals to a single PC/XT/AT is a much more realistic and cost-effective approach to increased office productivity. The argument can be made for the use of multiple, cheap, clone PCs in such a situation, but how many businessmen would want multiple copies of their accounts-receivable file or inventory file on several different machines? I believe that multiuser operating systems such as Digital Research's Concurrent DOS definitely have their place in the world. They may not necessarily fit every situation or need, but then neither does the more simplistic environment provided by the current versions of MS-DOS."

I don't agree with all of Mr. Mullan's arguments, but for once I am going to pass up my prerogative as the columnist to have the last word on the subject. Further comments on the alleged need for multitasking, multiuser operating systems in personal computers are solicited from *DDJ* readers!

DDJ

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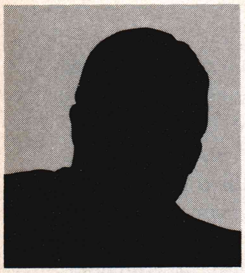
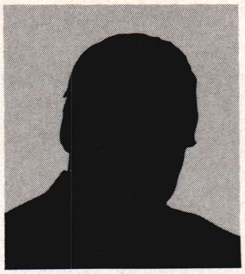
"Multiple windows."

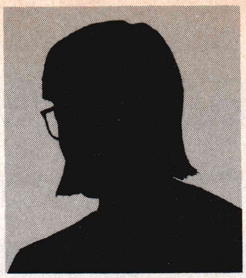


"Emacs runs on MS-DOS, VMS and UNIX. It's my company's standard editor."

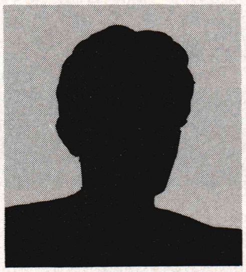


"I can run a shell or DCL command session even while editing."

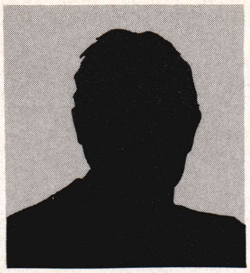
"A hundred times better than the UNIX vi editor."



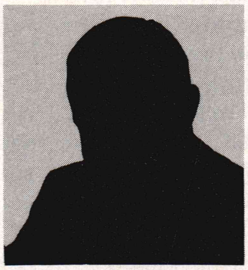
"Programming modes to assist me in writing C, Pascal, ADA and Lisp."



"UniPress really supports Emacs on Berkeley and AT&T UNIX, and is constantly developing Emacs."

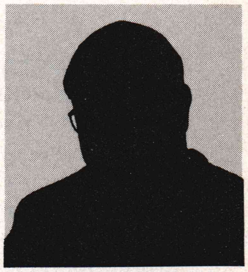


"I can associate any command to any keystroke sequence."



"Emacs automates the code-compile-edit-debug process."

"Electronic mail is only one of the many included packages I use."



"I can create my own customized editor commands with the MLisp extension language."

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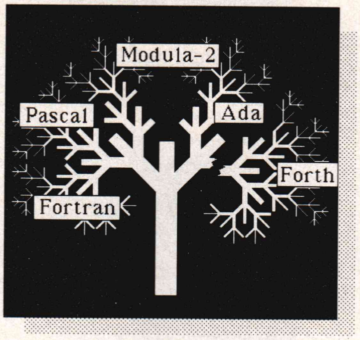
Forth: Philosophy, Standards, and Practical Advice



Programming is control; languages that most directly give the programmer control touch most deeply the programming impulse. That's the appeal of assembly language: *mano a mano* with the machine's bare metal. Those who prefer high-level languages find in Forth an edge-of-the-envelope programming environment. What's it like out there?

Forth puts the programmer into intimate contact with the insides of the language, unlike other high-level languages whose compilers are black boxes. The Forth compiler consists of instructions in Forth itself—the compiler's *right there*, where the programmer can reach out and touch it, not locked away on the other side of some impenetrable barrier. Reach out, touch it, and put a little spin on it.

Programming in Forth consists of adding new commands to the language. The programmer-created commands climb latticelike to the solution. The command at the top is the program; when executed, it answers the question posed by the task. This topmost command is defined in terms of commands lower in the hierarchy, and those commands are defined in terms of commands lower still. (Though recursion in Forth is possible, it is not used as often as it is in, say, LISP.) The program's foundation is a small set of primitives written in the language of the computer on which the program will run.

The program may also contain a few assembly-language commands

by Michael Ham

added by the programmer at speed-critical parts of the application. Most of the program, however, will consist of commands written in Forth:

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some constitute the Forth nucleus, some are the programmer's own general-purpose tool words, and the remainder are specific to the problem at hand. Some of these programmer-created commands extend the compiler. But first let's look at the programmer's tools.

Over time, Forth programmers create or collect a set of tiny tools that they graft onto the Forth they use. (Every Forth implementation provides a way for its user to customize it through the permanent addition of new commands.) Tiny tools percolate through the community of Forth programmers and in time become assimilated as regular Forth words. *NIP* and *TUCK* are close to becoming a part of generic Forth. A few tiny tools are shown in Listing One, page 104; do you know their authors? Before their origins are forgotten, we should acknowledge their creators and refiners. Send in your own favorite tiny tools (with attribution if you can), and I'll publish them for general consumption to expedite the diffusion.

In addition to these tiny tools, programmers build larger tools as well. These are generally shaped by the kind of applications the programmer writes. Later in this column, I describe (as a challenge to you) a number-input tool I have developed. I would be interested in seeing your solution. I'll include the best solution I get (or, by default, my own effort) in a future column.

Extensions to the compiler (which at first I avoided altogether) are the source of some of Forth's magic. Extensions are of two types: the *CREATE . . . DOES>* defining commands normally used to add new data classes and the *IMMEDIATE* words that can be used to make new control structures. Let's examine the *CREATE . . . DOES>* commands now and save the *IMMEDIATE* guys for a future column. With a defining command you can create a family of structures in which all members obey the rule laid down in *DOES>*.

Suppose, for example, you will be using a variety of arrays in some application. Most Forths don't provide an array-defining word: an array-creating command is easy to write, and different situations demand different array specialties. Some programmers might want the array to do a range check on indices; others (such as myself) prefer to do any necessary edits before the indices are passed to the array. When some internal program routine generates the indices within definite bounds, range checking would sacrifice speed unnecessarily. I discuss a series of variations on an array-defining command later in this column.

Because Forth doesn't have a "hands-off" compiler whose internals are secret, Forth application programmers are led within the language. They work outward toward their application, but at the same time they work inward to tinker with the language itself. You don't even have to scratch a Forth application programmer to find the systems programmer within: the systems programmer is right there, working alongside the application programmer. In the array-defining commands, for example, you work toward adding a kind of type declaration to the language, a function already embedded within the compilers of many languages: in those languages, however, you usually don't have a chance to make it work in the way you want.

Every Forth programmer spends some time working on the language

itself as the application. The systems enhancements become part of her or his toolkit for future work, and Forth grows vinelike to enclose the programming problems most often encountered.

Forth is by design an open-architecture language. An accident of history plunged Forth programmers deep into that architecture from the beginning. The first Forth products, sold by FORTH Inc., were beyond the financial reach of hobbyists. So a band of programmers, the original Forth Interest Group (FIG), developed public-domain Forth systems to promulgate the language to hobbyists and hackers. The fig-Forth systems were distributed in the form of source-code listings, so early Forth users were willy-nilly systems programmers as they typed in the code and tuned it to their needs. Many commercial Forth products were built upon and grew out of these early fig-Forth listings. Control of the machine was sublimated into control of the language.

Forth Standards

Because Forth so readily grows in every direction, standards were needed to define a common core. Three standards have come to be, the later supplanting the earlier. The first was the FIG standard, a de facto standard created by the popularity and widespread distribution of those early FIG listings. This was followed by the 79 Standard, the first attempt at a formal and deliberate standard. The 79 Standard benefited from hindsight: It contained what the original fig-Forth would have included if its creators had had more Forth experience instead of learning while doing. The latest standard is the 83 Standard—an effort to polish, refine, and extend the 79 Standard.

In most of the computer industry's standards efforts, intense conflicts arise between unassailable logic (my position) and pointless pig-headed resistance (your position). This dynamic could also be detected in the development of the 83 Standard. When the 83 Standard was announced, the Forth community's delight at discovering refinements (read: changes) from the 79 Standard was muted. The spirit of innovation had acquired a conservative cast.

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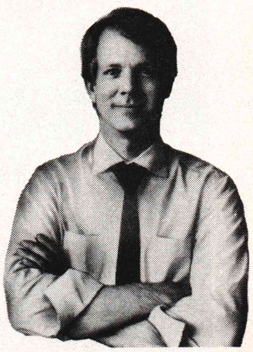

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STRUCTURED PROGRAMMING
(continued from page 113)

Those moving up to 83 Standard Forths should take note of Ray Duncan's article "Converting FIG-Forth to Forth 83" in the May 1984 *DDJ*, Robert Berkey's two articles entitled "79-Standard to 83-Standard" in *Forth Dimensions* (vol. 6, nos. 3 and 4), and Kevin McCabe's review of the 83 Standard in the August 1984 issue of *Byte*.

The 83 Standard defines the behavior of a core of Forth words. Several different Forths adhere to the 83 Standard; their standard words work in the prescribed manner, though they may differ in speed of execution because of the differences in how they were implemented. The extensions (such as the file-support system) to these Forths are not governed by the standard and thus may differ considerably, and a particular Forth may be tuned to a specific machine—for example, it might support function keys and a speaker, both of which go beyond issues addressed by the standard.

Several implementations of 83 Standard Forth are available. Laboratory Microsystems and Micromotion have 83 Standard Forths for a variety of computers. Harvard Softworks has an overlay file that makes its Forth meet the 83 Standard. F83, a Forth written by Henry Laxen and Michael Perry, is a public-domain version of an 83 Standard Forth.

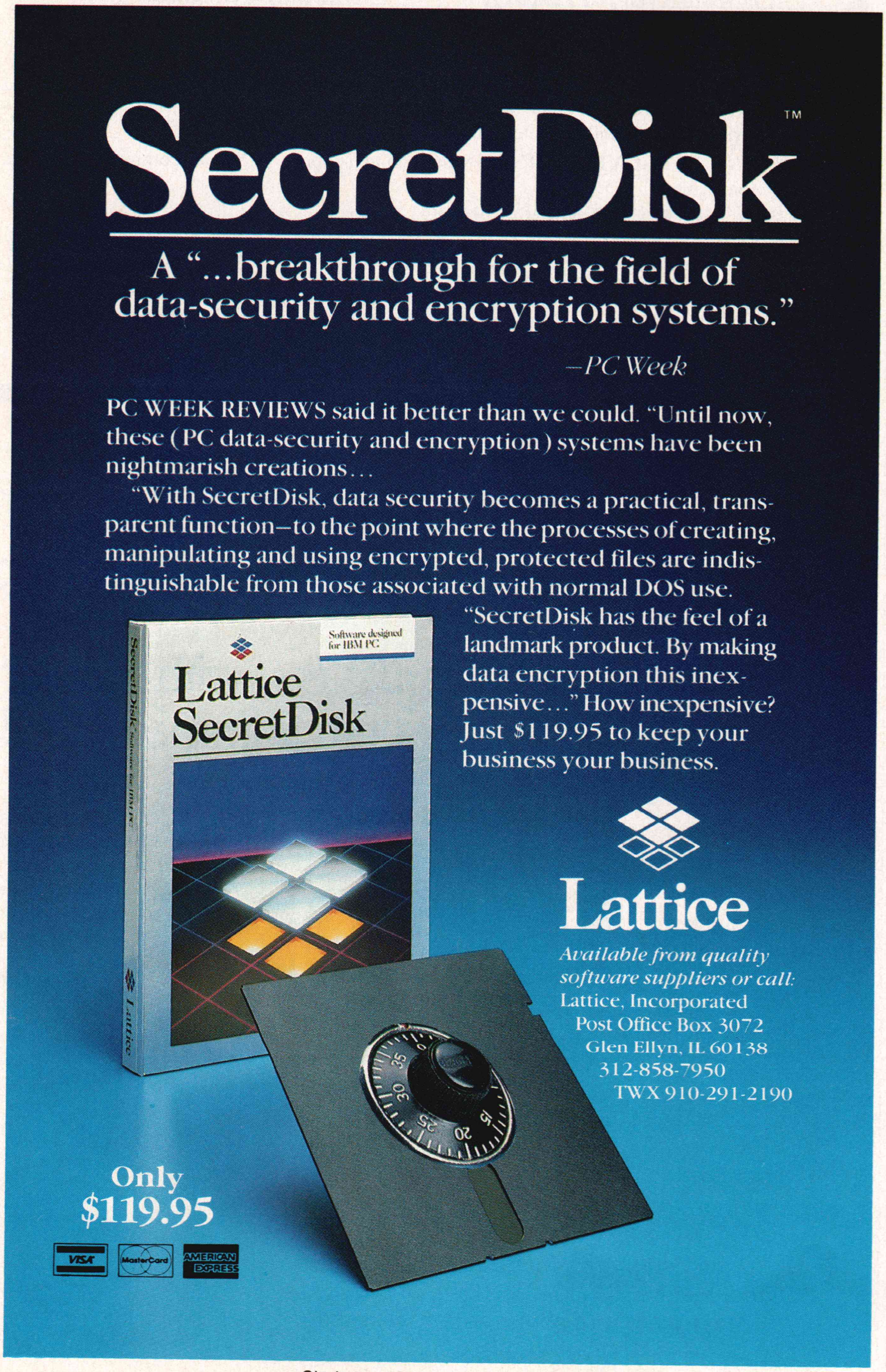
Because the 83 Standard specifies only a 16-bit implementation, 32-bit Forths (which can address more than 64K of instruction space) are by definition nonstandard. Some 32-bit Forths, however, (such as Palo Alto Shipping Company's Forth for the Macintosh and LMI's Forth+ products for the 8088/8086 and the 68000) strive to be standard in all other respects.

Although the 83 Standard will probably stand as the latest effort for quite a while, it fails to address some important topics: floating point (a de facto standard seems to be emerging), graphics, and a standard implementation for Forths that inhabit memory beyond 64K. These issues are necessarily being addressed by Forth vendors, and a consensus may in time emerge and be recognized in a later standard.

Where Is It Used, and Who Uses It?

Forth is well known as a language for data acquisition and machine and process control and is often the high-level language hiding inside the ROM of an intelligent machine. But Forth is found laboring in other vineyards as well. Business applications, for example, are not commonly thought of as Forth territory, but Forth was in business from its commercial birth. When Forth emerged from its womb of astronomical telescope control and was delivered to FORTH Inc.'s first customer, it was for a business database system in a custom application. How many of you are writing Forth code to address applications that might be thought of as food for COBOL?

For that matter, what is the range of application areas addressed by Forth? Many software products don't reveal their lingual origins unless the language in question is riding high or deemed especially appropriate for the given application area. Do you



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know accounting packages that are unexpectedly Forth at heart? Databases? Games? Instructional programs? I would like to hear about intriguing uses of Forth. Send me information that I can print, and let's see what an honor roll of Forth programs looks like.

Forth programmers are an interesting lot. Compared to programmers of most other languages, relatively few Forth programmers have degrees in computer science. Many (most?) are self-taught programmers: they had a project that involved some programming and found Forth a good tool—easy to learn, quickly productive, and well adapted to an experimental approach. These characteristics result from Forth's evolution: a working language shaped in the field by a programmer who had to fit big solutions into small computers in little time.

Forth programmers include a high proportion of hardware-oriented people who enjoy working at the boundary between software and hardware, using knowledge gained by experimentation and experience. Forth programmers abhor protective protocols and demand the ability to grab the guts of the hardware and software. They are an innovative lot, generally impatient with theory in their eagerness to get the job done. They are willing to share their idea but are sometimes reluctant to change their own approach. This leads to the reinvention as well as the refinement of techniques.

Where Can You Talk with Them?

Forth people are scattered across the country. Many are members of the Forth Interest Group [P.O. Box 8231, San Jose, CA 95155; (408) 277-0668]. FIG publishes a journal and also has a 300-baud bulletin board for discussions (no files). It's at (415) 962-8653—press two carriage returns when you connect. FIG's local chapters across the country provide opportunities for face-to-face contact.

DDJ includes Forth offerings in its own CompuServe forum (GO DDJ at the ! prompt). Creative Solutions, a Forth vendor, also hosts a Forth discussion group on CompuServe (GO FORTH). Two exclusively Forth bulletin boards are the East Coast Forth BBS [(703) 442-8695] and the West Coast LMI BBS [(213) 306-3530]. Both operate at 300/1200/2400 bps, are available around the clock, and include both discussion and files of source code.

A Look at Arrays

Array-defining words are the five-finger exercises of defining words. It's easy to extend the compiler to build arrays that match your taste and needs exactly. Listings Two through Eight trace one path of development for an array-defining word.

Listing Two, page 104, shows a first attempt. Though this is certainly good enough for workaday use, it has a couple of drawbacks: it defines arrays only for single-precision numbers, and the use of *ARRAY* for the name, though an obvious choice, results in awkward and un-English phrasing in the source code.

You will note that the stack comment following *DOES>* contains one address in angle brackets. This is the address that *DOES>* places on the stack at execution time. I look at the stack comments as I write the definition, and if I slip and forget that this address is present, I write bugs. I put the address in brackets to indicate that it is supplied by the word itself.

Listing Three, page 104, shows a more flexible array-defining word: It can create an array of bytes, cells, or double-precision numbers. The name *FOR* is used instead of *ARRAY* to make the code read more naturally. Picking good names for Forth words is a difficult art; you can be led astray by an impulse to name words according to their internal implementation rather than with an eye to their use.

At creation time, *FOR* stores the array type (the number of bytes an entry occupies) into the first byte of the array area and initializes the rest of the array to 0s. The index is presented at execution time, and the type is retrieved (with *COUNT*). The product of the type and the index then gives the offset to the entry, and this offset (possibly 0) is added to the address of the first entry.

This definition, however, makes the programmer pick the correct storage or retrieval word. Every decision the programmer makes represents an opportunity to decide incorrectly. Moreover, if I happen to use the wrong storage or retrieval word, it is hard for me to spot the error. If the right kind of word is in the right place, it looks—well—right. If I use *@* with a byte or double-precision array (when I should have used *C@* or *2@*), the result is wrong, but I have a devil of a time seeing the error, even when I am looking at it.

Listing Four, page 104, shows one solution: give that responsibility to the array word. The flags *PUT* and *GET* determine the direction in which the datum will move. When the array word is executed, the *DOES>* clause of its parent *FOR* uses the type number (a copy of which it momentarily stashes on the return stack while it does other work) to dip into either *STORES* or *FETCHES* to retrieve the correct operation to perform. (The command *]* turns on the compiler, and so the stores and fetches following are not immediately executed; rather, their (2-byte) addresses are stored into the dictionary. The *[* turns the compiler off again.)

I often use bit arrays to save room. Listing Five, page 104, shows my collection of bit tools; these appeared in a slightly different form in an article in *Computer Language*. The prefix + for "turn on" and − for "turn off" follow naming conventions suggested by Kim Harris (see later). I use ~ as a prefix meaning toggle. *@BIT* uses the word *FLAG* to force nonzeros to the 83 Standard Boolean value for true (−1) so that the fetched value will work appropriately with logical operators such as *AND* and *OR*. You should note that the *NOT* in the definition of *−BIT* is the 83 Standard *NOT*, which operates bitwise (as do the other logical operators *AND*, *OR*, and *XOR*). The 79 Standard *NOT* was merely a synonym for *0=*. If you have not yet moved to an 83 Standard Forth, you should replace *NOT* with *−1 XOR*.

The *FOR* in Listing Six, page 104, can also create bit arrays. For arrays of bytes, cells, or doubles, this *FOR* works exactly like the *FOR* in Listing Four does. The range of values that can be stored in a bit is limited, so I embed the *PUT* function in *SET*, *ZAP*, and *FLIP* to make the phrases read better in the bit context.

At one time I would have stopped here. But Kim Harris has pointed out that whenever you create a new data structure, you should also create a word to display its contents. These

(continued from page 115)

"inspection" words inevitably repay their development cost as soon as you begin to use the new structures. (Think of trying to use the stack without *.S* to let you look at what's there.)

So I go one step further. The display word needs to know how many elements to display, so a new *FOR* is shown in Listing Seven, page 105. This *FOR* stores the number of slots as part of the array information. I then need a word to move past the cell holding the array size to the byte where the type is stored. Rather than put this step in the definition as a (subsequently) mysterious *2+*, I factor it out for separate definition as *>TYPE*. If I move to a 32-bit architecture, I'll know to modify this word accordingly. *>DATA* is defined similarly.

My first impulse was to have *SPILL* just be a constant with a negative value. *FOR*'s *DOES>* clause would then be modified to first check the sign of the index. If the index was positive, *DOES>* would do its usual work of storage and retrieval; if the index was negative, *DOES>* would know that what was wanted was a display of the array contents and it would include the code for that.

I rejected this approach, even though *FOR*'s definition could still be made readable by factoring out some of the subfunctions. The display function is only for development, but *FOR* is a production word and so it should not include development tasks. By defining the display word separately, I don't have to include it in the production version of the program.

Listing Eight, page 105, shows the development of *SPILL*, which expects to be followed by the name of an array. *SPILL* displays only five double-precision numbers per line because of their potential length; otherwise ten array entries are shown per line. *}LINE* starts a new line when appropriate. My naming convention for words that execute conditionally is to use *}* as a prefix. This doesn't match the example of *?DUP*, but I prefer to restrict my use of the prefix *?* to words that expect a flag. You can read *}* as "maybe."

In my first iteration of developing the bit display, bits were shown in the "natural" way, as 0s and 1s. [Because *@BIT* converts bits to Boolean flags (0 and −1), I used *NEGATE* to produce more conventional bit values (0 and 1) for the display.] On testing the word, however, I found that I couldn't see the 1s for the 0s. So I revised the display to show "off" bits as hyphens. The 1s of the "on" bits then stand out nicely.

I assumed that an array will have fewer than 10,000 elements, and so the line label is set to have at most four digits. In fact, the display word, like the array word, reflects any number of assumptions about how the data should be presented. These reflect my taste and requirements. (Two examples in addition to those mentioned above: even though the final *FOR* knows the number of slots in the array, I still prefer that the array word not perform a range check on the index; and single-precision numbers are displayed with *.* instead of *U.* because the arrays I use are more likely to contain negative numbers than addresses.) It is the strength of Forth that you can tailor these tools to suit yourself.

Naming of Parts

I have learned the hard way that *JOAN* and *JOHN* would be poor names for program words. Not only do they fail to tell the reader what is going on but they also are spelled the same except for the difference of a single letter and (worse) they are the same kind of word. You might type "H" when "A" is intended. The error will be accepted because *JOHN* is a valid word. The program will even work after a fashion because *JOHN* and *JOAN* fulfill similar functions. And once again I would be trying to find a bug that consists of the right kind of word—but not the right word—in the right place. Whenever possible, I make sure that names differ by more than a single letter.

Another poor name choice that I considered briefly was *TO* for *PUT*. The problem with *TO* is that it is a homonym for *2*. Homonyms are an annoyance when you try to talk about the code.

If you ever use hex, it's also a bad idea to use names that could be numbers. This problem can be alleviated by making it an absolute rule to write hex numerals with a leading 0.

A pattern of naming Forth words has developed slowly. Kim Harris has compiled a reasonably large set of naming conventions that seem to be generally accepted. These have been published as an appendix to Leo Brodie's *Thinking Forth* (Englewood Cliffs, N.J.: Prentice-Hall, 1984) and as papers in the *1984 Rochester Forth Applications Conference Proceedings* and the *1983 FORML Conference Proceedings.*

A Number-Input Word: Challenge to Readers

Programmers often want users to enter numeric information. The challenge is to develop an easy-to-use command with a user-friendly face. I'll now discuss some suggested design specifications.

Each digit is displayed on the screen as it is entered. The display is "calculator" style, with digits appearing (and disappearing) at the rightmost end of the number. The routine inserts commas in the display as needed. The minus key operates as a toggle (which accommodates the usual entering the minus sign at the beginning but also permits it to be turned on or off after the number is underway). Backspace and Delete (and any other left-arrow key you might have on your computer) rub out the rightmost character (which might be a minus sign or a decimal point). The remaining characters in the field shift one place to the right to fill the gap. Entering "B" or "C" (uppercase or lowercase) erases everything that has been entered. Entering any illegal character or attempting to delete when the field is blank results in a beep. Thus every key either produces some alteration in the display or sounds a bell.

If the user enters a 0 to start, entering additional 0s immediately thereafter does not result in a repeating series of 0 (unless, of course, a decimal point was entered first). Other digits do repeat. As a courtesy to the user, the letter *l* (uppercase or lowercase) is accepted as the number *1* and the letter *o* as the number *0*.

The programmer specifies whether a minus sign is allowed; if it is not, pressing the minus key produces a beep but no entry. Similarly, if the programmer indicates no decimal places, the decimal point is beeped as

invalid input.

The format of the commands the programmer uses to manipulate the routine in his or her program is as follows:

1. n PLACES—*n* is the number of places to the right of the decimal point. The value presumably is stored in a variable. The number the user enters is collected as a double-precision integer, so the number of decimal places is a scaling factor. A decimal point is a legal character for the user to enter only if the number of places is greater than zero. The default is zero places. If the user presses Return after entering only the whole-number portion of a number with decimal places, the decimal point and trailing 0s are supplied by the routine.
2. NEG-OK ON—*NEG-OK* is a variable. The default value is false (off). Minus signs are accepted only if *NEG-OK* is on.
3. d n −1 DIGITS or n 0 DIGITS—The true/false flag (embedded in some mnemonic name) tells the routine whether it is being supplied with a number to begin with. If the flag is true, the (double-precision) number is displayed in the entry field (with commas, minus sign, and decimal point as appropriate) for the user to accept or alter as needed. If the flag is false, no number is supplied and the routine begins with a blank entry box.

The single-precision number *n* specifies the total number of digits the user may enter. This value, together with the number of places, determines the number of digits allowed to the left of the decimal point. The sequence *2 PLACES 5 NEW DIGITS*, for example, means that there will be at most three digits to the left of the decimal point and at most two digits to the right. (*NEW* here is assumed to be a constant equal to 0.)

DIGITS presents an inverse-video field at the current cursor location. The field allows room for minus (but only if *NEG-OK* is on), for commas (but only as many as can be entered given the number of digits allowed), and for a decimal point (but only if more than zero places have been specified). The field includes a blank inverse space before and after the spaces needed to hold the number, sign, commas, and decimal point of the number being entered.

When the user signifies the end of input by pressing the carriage return, the stack contains a double-precision number (the value of the entry) under a single-precision number (the number of digits the user actually entered). This allows the program to distinguish "no entry" from an entered 0.

Send me your own solution, preferably in an 83 Standard Forth. In a future column, I'll take a look at the results.

Operating Systems and Text and Block Files

Forth was originally its own operating system: It seized control of the entire computer and handled everything itself. This Forth operating system included a simple and effective way to access the disk directly using a block number. Each block was 1K, and source code was displayed on the screen in one-block chunks, so blocks were also called "screens."

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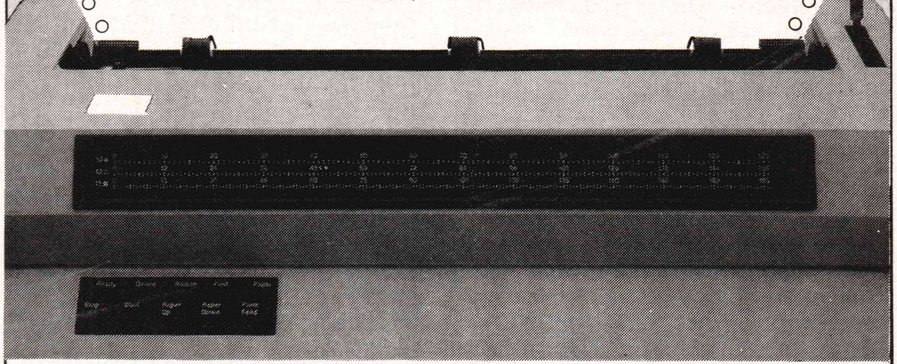

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STRUCTURED PROGRAMMING
(continued from page 117)

disk storage became more common, the omnipresence of the operating system became inescapable. Few users were willing to reboot between applications simply so that Forth could run its own show, and fewer still wanted to partition their hard disk to allow different disk formats to share the space. (Embedded applications do not have this problem, of course, and the Forth operating system is still often found in that environment as well as in totally dedicated systems, such as for process control and data acquisition.)

Forth now commonly runs under an operating system and makes use of the operating system's I/O services. Blocks are still used, but in this environment they reside within files.

The efficacy of the block files is a topic of perennial debate. Some programmers prefer text files so that they don't have to group the source code into 1K blocks. Others accept the modular discipline of the 1K chunks and as a bonus retain the the ability to incrementally compile a module under development. That is, they load and test a block until it works; write, load, and test the next block; and so on—instead of reloading the entire file with each change. Block files, with their separately loadable blocks, fit the interactive program development style that is Forth's special tactic.

One practice sometimes seen in block files—using block-number ranges to create subfiles within a file—seems worth discarding. Within a block file a programmer might use, for example, blocks 5–10 are for one module, 15–25 for another, 30–40 for a set of data pointers, and block 50 and beyond for the data. These block-number ranges are a hangover from the "file" systems typically used in native-mode Forths, when the only disk access was by block number.

The gaps in the block ranges are intended to simplify expansion and maintenance of the "subfile" system. Because Forth stores 1K per screen, though, this technique eats up too much storage room in operating systems such as MS-DOS or PC-DOS, where files cannot have gaps. Moreover, adding blocks to accommodate new functions will often throw a monkey wrench into the numbering scheme and invalidate the block numbers in the load block.

It is simpler and more efficient to exploit the strengths of the file system and use different files for separate submodules of source code. Forths running under an operating system will include a complement of file-handling words so that the program can open and close files as needed. Different files of Forth source code, whether block or text files, can be called during a load sequence with some word such as *INCLUDE*. The load block, instead of specifying block number ranges, can *INCLUDE* specific file names, and those files can expand or contract as the program is maintained and revised, with no effect on the load instructions.

Indeed, if a particular submodule (for example, the number-input routine described earlier) turns out to be generally useful, it is quite handy to have it as a file of its own to be *INCLUDE*d in as many programs as needed. Some Forths allow the developer to create small, relocatable binary overlays so that such modules can be called quickly and serve as a component of a Forth library of tools.

Factoring modules into separate files is an extension of the idea of factoring functions into separate words. A Forth programmer learns through experience when a routine deserves its own identity, whether as word or as file.

There's no denying, however, that blocks, whether in files or in native mode, consume a lot of disk space. Most of this is because of their puffiness: a block occupies 1K of disk space even though a considerable part of that 1K may be blanks. That's why Forth programmers dearly love the archiving programs that squeeze out the blanks when the file is stored in archive format. My archived files are typically 20 percent of their original size. (This, of course, includes compression beyond merely squeezing down the blanks.)

The program I use is a shareware program called ARC. It is under continuing development by System Enhancement Associates (21 New Street, Wayne, NJ 07470). You can buy it from the firm for $50, but it prefers

that you obtain the program through the normal shareware distribution channels. Version 5.1 was released in January, but new versions appear with disconcerting frequency. A version can read and decompress archive files created by any lower-numbered version but not vice versa.

ARC builds archive files that contain as many compressed files as you want. You can add files to an archive file and extract them quickly whenever you need them; it is also easy to update an archived file with a later version. The use of ARC makes the bulkiness of the block file much less of an issue.

Background

I plan to be a regular denizen of these pages, so you might want some idea of my programming background and Forth experience. I started programming on an IBM 1401, and the language was Autocoder. From there I moved on to FORTRAN, dipped into BASIC, glanced at APL and Pascal, and at last discovered Forth through an article in *DDJ* several years ago.

I got a copy of Miller Microcomputer Services' MMSForth and found Forth irresistible. Because I wanted to share and sell my programs, I moved to Forth Technology's Forth/Level 2, a spin-off of FORTH Inc.'s polyFORTH. Forth/Level 2 required no license fees or royalties, and its *TURNKEY* word was an easy way to produce bootable programs.

Finally, however, I had to recognize that the world of business applications in which I worked was increasingly dominated by PC-DOS/MS-DOS. Native-mode Forths did not fit that environment comfortably, particularly as hard disks became more common. I moved to Laboratory Microsystems' PC/Forth because it worked well with DOS and because it was one of the few vendor-supported, 83 Standard Forths then available. It also required no license fees or royalties for turnkeyed programs.

I did not really consider a public-domain Forth. Because I write programs for a living, I want vendor support. I don't want to be the one who has to write every extension package and constantly track new technology and adjust my system to fit. I feel that my time is better spent on billable projects, and I am willing to pay the minor upgrade charges to have the vendor keep the system tuned to new machines and new versions of the operating system.

Currently I am completing a reasonably large Forth application (about a thousand screens), a software package that will be published RSN. I am also an outside contractor for Laboratory Microsystems, assisting with technical support and documentation—a natural progression from my own extensive use of the company's technical support.

From my experience, I know the above-mentioned Forths better than I do others, but I am sure that my readers will expand my horizons. You are welcome to write to me on the DDJ Forum on CompuServe or care of the magazine. I look forward to hearing from you.

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(Listings begin on page 104.)

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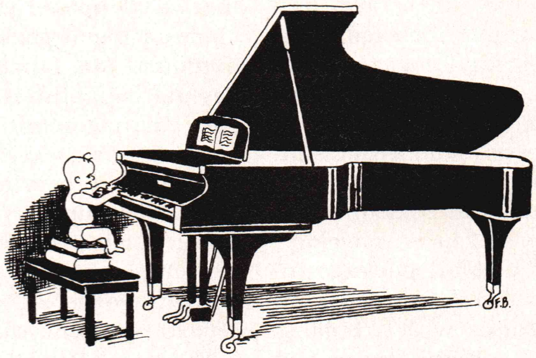

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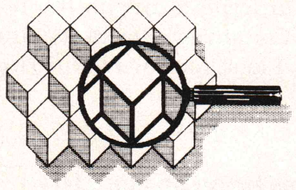

PCC/Systems has introduced cc:Mail for local-area networks. With this system, users of the IBM PC and compatibles can send, receive, store, and edit electronic message envelopes. Anything created on a PC, such as text, graphics, data files, and display screens from other software application programs, can be sent to another PC in an envelope. The cc:Mail package includes a full-featured word processor with a built-in, felt-tip highlighting pen and a graphics/drawing package. Users have a choice of color palettes and can edit materials from other sources. Screen content from any application program can be frozen to create snapshots, which can then be edited and inserted into messages. Each message can include any combination of up to 20 text, graphics, and file items. The starter package for ten users costs $995, and expansion kits are available.

Ashton-Tate has introduced the dBASE III Plus LAN Pack, designed to enable multiple users to share dBASE Plus files on a local-area network. Equipped with built-in multiuser and stand-alone capability, dBASE III Plus can network an unlimited number of users. Combining one dBASE III Plus with one LAN Pack provides a four-user network. dBASE III Plus and dBASE III Plus LAN Pack can run on any network that supports PC-DOS, Version 3.1, including the IBM PC Network, 3Com's 3Plus, and Novell's Advanced NetWare, Version 1.01, or later. Other LANs that use an operating system compatible with PC-DOS 3.1 can also be supported.

Kyss!, an advanced operator interface with system enhancement facilities, is available from **The Information People.** Kyss! includes a menu generator, extended DOS batch-processing capabilities, disk file management, job tracking, and a text display facility for preparing on-line instructions. The suggested retail price is $150 for single-user versions; network versions begin at $300 for six-user systems.

The MLink Data Communications System from **Corporate Microsystems** includes the Development System, a software package recommended for system developers. MLink also includes terminal emulation, an on-line help system, a configuration system, three file-transfer protocols, a script interpreter, a script debugger, a script assembler, 24 application scripts, and script source files. The system is designed to facilitate micro-to-mainframe, micro-to-micro, PC-to-Unix, and other data-communication links. Prices vary according to configuration.

Information Technologies' LinkUp 3270 SNA, 3270 BSC, and 3770 SNA emulations have been enhanced. The products feature foreground/background operations, enhanced multiple printing capacities, and up to 32 simultaneous sessions. They support printer output to standard DOS printers, a high-speed serial printer, and spooling of print files to disk. All modes can be driven simultaneously. The stand-alone coprocessor version is available for $995.

VersaLAN is a local-area network solution from **Software Clearing House** that includes software, hardware, and wiring. VersaLAN can handle up to 32 PCs and is compatible with PC-DOS and MS-DOS and the IBM PC Network. It also has software hooks so that advanced users can program it to add functions such as private data encryption or links to user-written software. In addition, VersaLAN features electronic mail, file transfer between micros, and hard disk and printer sharing. The product costs $250 per PC; additional PC connections cost from $175.

Polygon Associates has enhanced its poly-COM/240 terminal-emulation and file-transfer communication software package. The package now offers hot-key control for switching between a DOS screen and VAX terminal session without losing the communication link, instant toggle between text and graphics modes, host control commands for unattended or distributed applications, and a screen-saver function that blanks the PC screen after a defined period to reduce video screen wear.

Security

Several products that guard against unauthorized computer access are available from **Digital Pathways.** The Defender IID provides direct-dial user verification. The verification process takes only one phone call, requiring a valid access code, password, and/or SecureNet Key validation. The Defender IIk is a data encryption manager for highly secure dial-up links. It enables remote users with PCs to install an encryption board to protect data in transmission. The SecureNet Key provides an additional level of security for any Defender II system. Each user is provided with a credit-card-size key that has been initialized with a unique key number. The user then arms the key with a personal identification number. Prices vary according to configuration.

Release 2.0 of **System Automation Software's** Logger computer resource monitor is a RAM-resident program that tracks and documents the everyday use of IBM PC, PC/XT, PC/AT, and compatible computers. The new version includes log-in security and a summary option in the reporting subsystem that summarizes computer usage by user, directory, and program and calculates the duration of each activity. Logger's retail price is $74.95.

Artificial Intelligence

XSYS is an advisory expert-system shell from **California Intelligence** that runs on IBM PCs. In a typical scenario, the system asks the user problem-related questions and displays selection menus, depending on which specialized knowledge base the user has selected to attach to the generic XSYS shell program. The system can also explain, step-by-step, its pro-

gress and conclusions during and after each consultation. XSYS' facilities include knowledge attributes, variables, and operators in the *if* and *then* parts of any rule, handling of uncertainty and negation, and automatic concatenation of hierarchically related knowledge bases. The system requires an IBM PC, PC/XT, or PC/AT with at least 640K and DOS 2.X. The license fee for a single-CPU copy is $995.

Borland International's fifth-generation language development system, Turbo Prolog, is designed to infer or derive information from stated facts. The PROLOG language employs a theorem-proving algorithm for logic programming in order to take a set of premises and arrive at an appropriate conclusion. The algorithm utilizes pattern matching and back tracking. Turbo Prolog is priced at $99.95 and is available for IBM PC and compatible microcomputers.

The GCLisp 286 Developer from **Gold Hill Computers** includes a memory interpreter that features lexical scoping and the ability to address up to 15 megabytes of physical memory. It also features a memory compiler designed to allow applications to run up to 15 times faster than normal. The GCLisp 286 requires an IBM PC/AT or compatible with at least 2 megabytes; PC-DOS 3.0 or later; one double-sided, double-density or quad-disk drive; and a hard disk.

Application Development

Orchid Technology's PCturbo 286e utilizes an 8-MHz 80286 CPU, 80287 match processor socket, and a 16-bit internal system bus. With the connection of an optional RAM card, the PCturbo 286e accommodates the Lotus/Intel/Microsoft Expanded Memory Specification. PCturbo 286e with 1 megabyte of RAM costs $1,195.

MasterSweep-File Maintenance Utility is a disk utility from **The Software Store** that gives users access to disk directories and files. It enables users to find, view, copy, print, rename, move, delete, or tag files, and it supports path directories under PC-DOS. MasterSweep costs $49 and is available for PC-DOS and CP/M-80 computers.

PRO-C is a software package from **Majic Software** that steps a developer through an application definition and then generates a C program. The product comes with a half-megabyte of context-sensitive, on-line help that is available at the touch of a key. Its generic record-retrieval mechanism allows users to interface a generated program with an existing file system. Alternatively, users can select the interface to industry products such as Btrieve and C-ISAM. The C compilers currently supported by PRO-C are Microsoft's Version 2.0, Lattice's Version 2.15, Computer Innovations' Version 2.3F, and DeSmet's Version 2.4. PRO-C costs $195.

Fort's Software has announced V-EMM, the Virtual Expanded Memory Manager. V-EMM provides up to 8 megabytes of virtual expanded memory and can execute many unaltered programs that support the Lotus/Intel/Microsoft Expanded Memory Specification. The price is $89.95.

Calvert Computer Systems has released Professional Applications System (PAS) software for program developers. PAS consists of four programs: two for generating applications

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(continued from page 121)

and two for running them. Programs are menu-driven and support full-screen editing, color systems, function and arrow keys, and unlimited nesting of menus. PAS applications can run any .COM or .EXE program. The system requirements are MS-DOS, 256K, two 360K disk drives, and an ANSI.SYS driver. The product costs $49.95.

Specialized Systems Consultants has announced an IBM PC, PC/AT, or Xenix System V port for its Unix-based Hitachi 6301 C Cross Compiler. The port features a stack frame designed to minimize overhead, separate compilation and linking, a source-code optimizer, and a run-time library.

The Synergy Development Toolkit from **Matrix Software Technology Corp.** provides tools for accessing Synergy run-time function calls from a wide range of languages. These language gateways are designed for the IBM/MS Macro Assembler, Turbo Pascal, IBM/MS BASIC Compiler and Pascal Compiler, Lattice C Compiler, IBM/MS BASIC Interpreter, Microsoft C Compiler, and dBASE II/III. The toolkit features a font collection, compiler, manager, and graphics resource editor. The retail price is $395.

Microtec Research has introduced the ASM180 cross assembler package, a full implementation of a relocatable macro assembler for the Hitachi HD64180 microprocessor's specified assembly language. ASM180 is available on DEC VAX/VMS and MicroVAX/VMS. The assembler features a compatible instruction set and directives, conditional assembly, symbolic addressing, relative addressing, and symbol cross-reference listing. A binary license for the ASM180 is $2,000 for the VAX under VMS or Ultrix.

The following utilities are available from **Lattice**: Lattice Text, a collection of eight programs that provide a set of tools for examining and editing text files; Lattice Make, an automated product generator; Lattice Screen, which provides error tracking; and Lattice dBC III Library, which contains more than 70 C functions.

BlueFish, a software product from **Computer Access Corp.**, provides full text-management capability for users of IBM PCs and compatibles. BlueFish can handle correspondence, contracts, medical journals, government regulations, engineering specifications, legal research, insurance documents, or company personnel records. The software operates on a minimum configuration of a PC with 256K, one disk drive, and PC-DOS. The package comes in two configurations: an office-automation, full-test, management system with both build and search/retrieval modules; and a search and retrieval module designed for publishers of data distributed on optical or other mass-storage media. Site licenses start at $750 per site.

Languages

PforCe, a library of object-oriented functions and subsystems for C, is available from **Phoenix Computer Products Corp.** Written in C and assembly language, PforCe offers programmers both high- and low-level functions that are ready to use. High-level functions allow programmers to manipulate windows, screens of fields and Lotus-like menus, and databases as objects. Low-level functions give programmers hardware control and enable them to change defaults at will. Sophisticated subsystems are also offered. PforCe is available for Microsoft, Lattice, Computer Innovations, and Wizard compilers. It is priced at $395.

The Greenleaf Comm Library (Version 2.0), a programmers' tool supporting C, is available from **Greenleaf Software.** More than 120 functions are provided to support communications at up to 9,600 baud, up to 16 simultaneous channels, XON/XOFF and XMODEM protocols, and flow-control options. Version 2.0 supports PC-DOS and MS-DOS and retails for $185.

Absoft Corp. has added two members to the MacFortran family: MacFortran/020 and MacFortran/RL. Both were designed to take advantage of new high-performance Macintosh hardware, General Computer's HyperDrive 2000, and Levco's MAC Super 20FP. MacFortran/020 is designed to generate code for Macintoshes upgraded with an MC68020 CPU and MC68881 math coprocessor. MacFortran/RL is a series of replacement run-time libraries for MacFortran users using hardware floating point. It supports NS32081 boards, the MC68881, or General Computer's HyperDrive 2000.

FORTRAN-80 Utilities from **Cleydale Engineering** are designed to complement the Microsoft FORTRAN-80 compiler, which runs under CP/M-80. These utilities consist of an optimized, scientific, subroutine library; Forlib.Rel math addition; an escape sequence and control character generator for controlling peripheral devices; and three FORTRAN programming tools. Each subroutine module is furnished with a demonstration driver program. Subject areas include linear and nonlinear regression analysis for curve fitting experimental data, statistics, matrix operations, simultaneous equations, forward and inverse fast Fourier transforms, numeric integration, equation roots, and graphics. The entire package consists of 60 files occupying 238K of disk storage and is distributed in the standard single-sided, single-density CP/M format. The cost is $49.95.

TDI Software has released the UCSD Pascal compiler, which includes the p-System operating system, for the Atari 520ST. UCSD Pascal features support units for separate compilation, assembly-language procedures, full implementation of Pascal, and a full-screen editor. The product is available in a regular and a developers' version. In addition to the UCSD Pascal compiler and p-System operating system, the developers' version contains an M68000 assembler, a native code generator, a symbolic debugger, and assorted Pascal units for manipulating directories and performing systems work. UCSD Pascal for the Atari 520ST is priced at $79.95; the developers' version is priced at $149.95.

Philon's Fast/Pascal is a high-quality compiler developed for use by programmers in the scientific and educational communities. It is designed for the 16- and 32-bit environments. Programs written in Fast/Pascal are portable to other hardware/operating systems. It is fully compatible with IEEE standard floating-point real arithmetic, and system calls are executable from within

the language. The package also contains a set of run-time libraries, file-handling routines, and string-handling capabilities.

MasterForth, which is available from **Micromotion**, is an implementation of the Forth programming language that includes a 68000 macro assembler and a full interface to CP/M 68K. Relocatable utilities and transient definitions make it possible to run software packages, and a string package, screen editor, and resident debugger are standard features. MasterForth is also available for the Macintosh, the IBM PC family, the Apple II family, the Commodore 64, and CP/M Z80 machines. It retails for $125.

For IBM/Apple

Release 1.2 of TextBank from **Group L Corp.** offers improved performance through the use of extended memory, support for additional storage devices, several extensions to the search and user interface, profiles of the most widely used Dialog and BRS on-line databases to make information searchable when downloaded, and full support for individual text files of up to 20 megabytes. TextBank requires an IBM PC or compatible with 640K, a hard disk, and MS-DOS. It is available for $995.

The Polytron Version Control System (PVCS) from **Polytron Corp.** is a source-code version and revision management system for programmers or teams of programmers developing large or complex programs on PCs and networks. The system maintains the revision history of source files and chronological and historical records of changes. It reconstructs any prior revision of any module, defines a version as specified revisions of various modules, and supports branching from prior revisions. Disk space is conserved by an intelligent difference detector that stores only the difference between successive revisions of a module. A single-user licence is available for $395.

Show Partner, a memory-resident graphics editor with animation, is available from **The Marketing Channel**. One image can quickly and completely replace another, and wipe, split, and box effects perform their transitions along traveling event line edges moving up or down, left or right, together or apart, or in or out. Show Partner also offers a scroll effect in any of four directions, fade-in of a selected area, and two-part weave of an area. The program loads into RAM alongside other applications and can also work in a nonresident stand-alone mode. Text or graphic screens are captured from any source and saved as named files. The program has the ability to add or change colors, size rotate, move graphics, and add text to graphics. Show Partner supports IBM CGA and EGA displays as well as the AST ColorGraphPlus palette display, AST Preview, or Hercules-compatible monochrome graphics adapters. It costs $149.

Version 3 of **Portable Software**'s PortaAPL software package for the Macintosh is a full-featured interpreter for standard APL. PortaAPL features a full-screen editor, the ASCII character set option, and the Host File System option. Also, system functions are available for accessing many of the Macintosh toolbox ROM routines, such as QuickDraw graphics, communications, sound generation, and menus.

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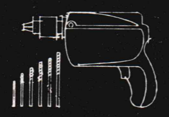

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OF INTEREST
(continued from page 123)

The package for the Macintosh is priced at $275. Current customers can upgrade to Version 3 for a $25 fee.

Reference Map

Absoft Corp., 4268 N. Woodward, Royal Oak, MI 48072; (313) 549-7111. Reader Service Number 16.
Ashton-Tate, 20101 Hamilton Ave., Torrance, CA 90502-1319; (213) 329-8000. Reader Service Number 17.
Borland International Inc., 4585 Scotts Valley Dr., Scotts Valley, CA 95066; (408) 438-8400. Reader Service Number 18.
California Intelligence, 912 Powell St., #8, San Francisco, CA 94108; (415) 391-4846. Reader Service Number 19.
Calvert Computer Systems Inc., 240 E. Main St., P.O. Box 95, Athena, OR 97813; (503) 566-3338. Reader Service Number 20.
Cleydale Engineering, Rte. 1, P.O. Box 217-B, Blacksburg, VA 24060. Reader Service Number 21.
Computer Access Corp., Ste. 324, 26 Brighton St., Belmont, MA 02178-4008; (617) 484-2412. Reader Service Number 22.
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Digital Pathways Inc., 201 Ravendale Dr., Mountain View, CA 94043; (415) 964-0707. Reader Service Number 24.
Fort's Software, P.O. Box 396, Manhattan, KS 66502; (913) 537-2897. Reader Service Number 25.
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Greenleaf Software Inc., 1411 LeMay Dr., Ste. 101, Carrollton, TX 75007; (214) 446-8641. Reader Service Number 27.
Group L Corp., 481 Carlisle Dr., Herndon, VA 22070; (703) 471-0300. Reader Service Number 28.
Information People (The), 443 Hudson Ave., Newark, OH 43055; (614) 349-8644. Reader Service Number 29.
Information Technologies Inc., 7850 E. Evans Rd., Scottsdale, AZ 85260; (602) 998-1033. Reader Service Number 30.
Lattice Inc., P.O. Box 3072, Glen Ellyn, IL 60138; (312) 858-7950. Reader Service Number 31.
Majic Software Inc., 224 S. Salisbury, Ste. C4, West Lafayette, IN 47906; (317) 743-0610. Reader Service Number 32.
Marketing Channel Ltd. (The), 120 E. Washington St., Ste. 421, Syracuse, NY 13202; (315) 474-3400. Reader Service Number 33.
Matrix Software Technology Corp., 50 Milk St., 15th Floor, Boston, MA 02109; (617) 723-8327. Reader Service Number 34.
Micromotion, 8726 S. Sepulveda Blvd., #A171, Los Angeles, CA 90045; (213) 821-4340. Reader Service Number 35.
Microtec Research, 3930 Freedom Cir., Santa Clara, CA 95054; (800) 554-5554, in CA (408) 733-2919. Reader Service Number 36.
Orchid Technology, 47790 Westinghouse Dr., Fremont, CA 95439; (415) 490-8586. Reader Service Number 37.
PCC/Systems, 480 California Ave., Ste. 201, Palo Alto, CA 94306; (415) 321-0430. Reader Service Number 38.
Philon Inc., 641 Avenue of the Americas, New York, NY 10011; (212) 807-0303. Reader Service Number 39.
Phoenix Computer Products Corp., 320 Norwood Park South, Norwood, MA 02062; (617) 762-5030. Reader Service Number 40.
Polygon Associates Inc., 1024 Executive Pkwy., St. Louis, MO 63141; (314) 576-7709. Reader Service Number 41.
Polytron Corp., P.O. Box 787, Hillsboro, OR 97123; (503) 648-8595. Reader Service Number 42.
Portable Software, 60 Aberdeen Ave., Cambridge, MA 02138; (617) 547-2918. Reader Service Number 43.
Software Clearing House Inc., 771 Neeb Rd., Cincinnati, OH 45238; (513) 451-6742. Reader Service Number 44.
Software Store (The), 706 Chippewa Sq., Marquette, MI 49855; (906) 228-7622. Reader Service Number 45.
Specialized Systems Consultants Inc., P.O. Box 55549, Seattle, WA 98155; (206) 367-UNIX. Reader Service Number 46.
System Automation Software Inc., 8555 16th St., Silver Spring, MD 20910; (301) 565-8080. Reader Service Number 47.
TDI Software Inc., 10410 Markison Rd., Dallas, TX 75238; (214) 340-4942. Reader Service Number 48.

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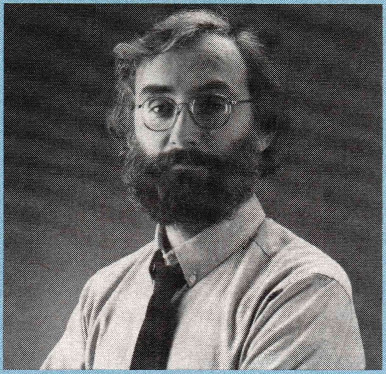


The declaration that some British colonists on this continent made of their independence 200-odd years ago this month was not the first rebellion against a regime regarded as tyrannical, of course; nor was the government they later formed the first democracy. Nothing ever happens for the first time.

The authors of the Declaration of Independence were particularly eloquent in their defense of the rights of the nonindentured adult white male, and over the succeeding centuries various of their descendants have been eloquent about the need to extend recognition of those rights to all Americans. Others have been equally eloquent about the need to deny such rights to blacks, women, homosexuals, and people of suspect ancestry in time of war. Americans are often eloquent on the subject of independence, even if a little afraid of it in practice. Just think what they'd be like if they were as independent as they are eloquent. Why, they'd be like Forth programmers.

Forth programmers seem to be a particularly independent bunch. The common explanation, which is probably correct, is that the language encourages independent thinking. If so, it fully justifies this special Forth issue, our sixth. Events in the Forth community are no less interesting now than in 1981 when we started this annual tradition. In last year's Forth issue, you may recall, Leo Brodie led a tour of the architecture of the then-new Novix Forth chip, a structure for which Forth creator Charles Moore did the blueprints. Now Harris Semiconductor has acquired a Novix license and is supplying bit-slice versions of the design. What this added support could mean to Novix and to Harris will be determined by the Forth programming community. Predictions are foolhardy.

It had been exactly two years, I remarked last month in this space, since we had reviewed Borland's Turbo Pascal, and now here was Turbo Prolog knocking at the door. Well, not exactly at the door, but I did finally manage to get my beta and final versions of the new Turbo Prolog without driving to Scotts Valley and have since been comparing notes on the product with Juergen Fey, an editor with *PC Magazin*. (*PC Magazin* is the magazine that Markt & Technik, M&T Publishing's Prussian parent publisher, puts out for the fairly technical PC readership in West Germany, and Juergen is one of its more technical editors.)

Turbo Prolog is PROLOG, Juergen thinks, in the same sense that Turbo Pascal is Pascal. The user interface is excellent, the performance is fast, and there are many extensions that overcome deficiencies of pure PROLOG. The result—our preliminary impression only—is that Turbo Prolog is at least a very good environment for learning Turbo Prolog. Beyond that—well, we are planning to review the product in the near future, and we'll evaluate it as a language implementation for first-time users, as a serious development environment, and as a PROLOG implementation. We'll consider what its existence, price, and ease of use could mean for the spread of PROLOG, and we'll evaluate its speed in light of Borland's claims and determine what the programmers gave up for the speed they got.

Borland has taken some brave steps in the past; I wonder if its independent spirit will be affected if the company goes public this year, as seems likely.

As an editor and writer I count the freedom to read among those rights alluded to at the top of this page, and I would not be an editor if I failed to bring to your attention the cloud of censorship that is once again moving over this country. It's starting with "adult" (i.e., adolescent) entertainment, with guidelines on the treatment of sex in films and the removal of *Playboy* et al. from convenience stores. *DDJ* isn't in the prurient interest business, of course, but we are currently running an on-line conference on the politically charged issue of data encryption, and I doubt that the cloud will stay over someone else's backyard for long.

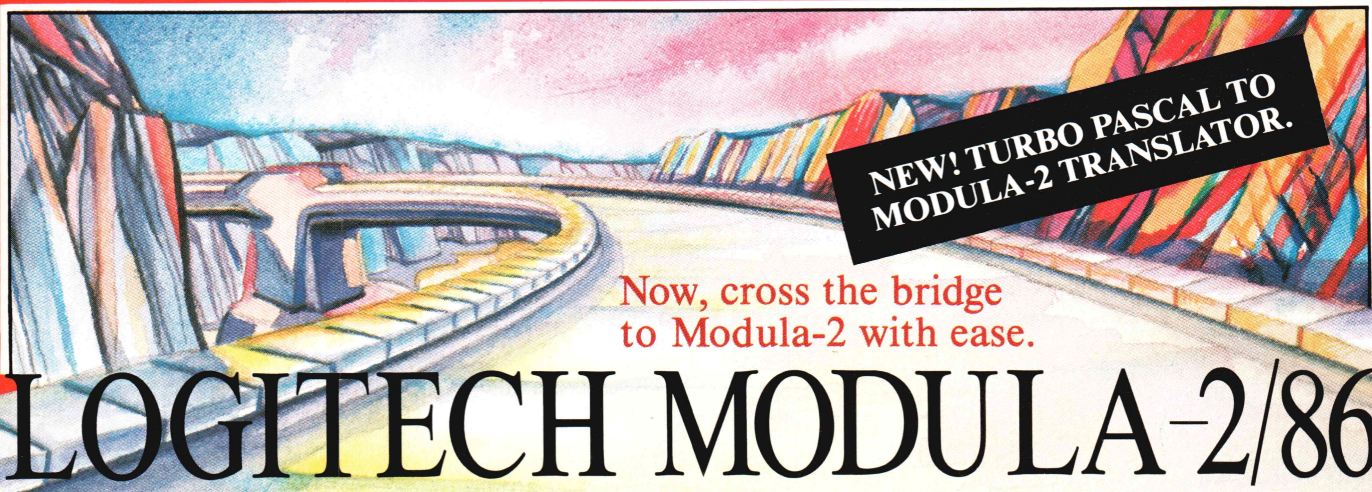
Ray Borrill, a pioneering computer retailer, recently flamed to me about the wild crowd at the Midwest Computer Show in 1976, where he shared a booth with Bob Marsh and Steve Dompier of Processor Technology. It reminded me of the Atari and Commodore booths this year in Atlanta, packed with independent third-party developers. In the otherwise stuffy Comdex atmosphere, the air in those booths was almost giddy—almost evocative of 1976.

Desktop publishing was the big thing at Comdex this year, with laser printers and document scanners coming down in price. Phoenix held a meeting for 80386 developers to discuss setting 80386 standards before IBM does it. Despite a lot of talk that copy protection is going the way of King George, the Tories of Lotus seem unconcerned; meanwhile, Central Point Software, purveyor of guns to the rebels, is looking into supplying armor to the redcoats.

Michael Swaine

Michael Swaine
editor-in-chief

This is the Modula-2 compiler *everybody's* been waiting for...



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